VISION – 2025

NRCC – PERSPECTIVE PLAN

JUNE 2007

राष्ट्रीय काजू अनुसंधान केन्द्र

(भारतीय कृषि अनुसंधान परिषद्)

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NATIONAL RESEARCH CENTRE FOR CASHEW

(Indian Council of Agricultural Research)

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June 2007

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FOREWORD

Indian agriculture must continuously evolve to remain ever responsive to manage the change and to meet the growing and diversified needs of different stakeholders in the entire production to consumption chain. In order to capitalize on the opportunities and to convert weaknesses into opportunities, we at the ICAR attempted to visualize an alternate agricultural scenario from present to twenty years hence. In this endeavour, an in-depth analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) was undertaken to place our research and technology development efforts in perspective so that we succeed in our pursuit of doing better than the best. Accordingly, the researchable issues are identified, strategies drawn and programmes indicated to have commensurate projects and relevant activities coinciding with the launch of the 11th Five Year Plan.

Cashew after its introduction by Portuguese travellers in 16th Century has naturalized to the Indian climatic conditions and is presently grown in an area of about 0.855 million hectares with production of 0.573 million tonnes.

The National Research Centre for Cashew (NRCC) is our main Institute for conducting research at present which also houses the All India Coordinated Research Project on Cashew. In cashew, as many as 37 varieties have been released, of which 21 have the export grade (W 240 and below) kernels. Also several planting technologies and techniques to improve cashew production have been developed. In micropropagtion, regeneration of cashew from the seedling explants (nodal cultures) and micrografting technique for *in vitro* multiplication of cashew have been standardized. Commercialization of softwood grafting technique has enabled large scale production of quality planting material (grafts) of improved and high yielding varieties of cashew.

It is expected that realizing the Vision embodied in the document would further ensure that the NRC for Cashew, Puttur continues to fulfil its mandate to make Indian agriculture locally, regionally and globally competitive. The efforts and valuable inputs provided by my colleagues at the ICAR Headquarters and by the Director and his team at the Institute level for over an year to develop Vision 2025 deserve appreciation.

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February, 2007

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PREFACE

Cashew after its introduction by Portuguese travellers in 16th Century has very well adapted to the Indian climatic conditions and is presently grown in an area of 8.55 lakh ha with production of 5.73 lakh MT. Considerable progress has been made in cashew research since 1950. However, in view of the changing global scenario and liberalised economic polices of government of India, Indian Council of Agricultural Research (ICAR) decided to bring out Perspective Plan 2020 of all its constituent institutes. Accordingly, analysis of the progress made and future strategies to meet the challenges in the international market have been made and documented in the publication 'Vision 2020' of NRC Cashew in the year 1997.

In the WTO regime, events of far reaching implications have taken place in the last 9 years. Research in frontier areas has shown enormous opportunities; frontier sciences such as Bio-technology and Bio-informatics have progressed very fast and new protection regime has emerged. There is a need to harness the new opportunities available with the progress of science. Considering these developments, the specific issues suggested by Director General, ICAR, suggestions emerged during discussion meeting with Deputy Director General (Hort) in January 2005 and during 9th meeting of Research Advisory Committee of the centre during February 2005, the Perspective Plan VISION-2020 of National Research Centre for Cashew, Puttur was revised in April 2005. As per the instruction of DDG (Hort) vide his communication dated 29th September 2006 and the decisions taken and guidelines received during the meeting held under Chairmanship of Dr. G.Kalloo, DDG (Hort) on 23rd October 2006 at KAB-II, Pusa, New Delhi and during another meeting held under the Chairmanship of Dr. Mangala Rai, Director General, ICAR on 5-11-2006 at NASC, Pusa, New Delhi, the Perspective Plan 2020 was revised and extended to cover the period upto 2025. Accordingly, keeping in view of the growing demand for cashew and the likely change in the cashew scenario in years to come and to meet the challenges of attaining self sufficiency in raw cashewnut production, the VISION-2025 : NRCC Perspective Plan has bee prepared.

Our grateful thanks are due to organizations like Food and Agricultural Organisation (FAO), Cashew Export Promotion Council of India (CEPCI) and Directorate of Cashewnut and Cocoa Development (DCCD) for the published information on production, productivity, export - import and nutritional figures.

Thanks are also due to all the Scientists of this Research Centre for providing the necessary input for this compilation. It is hoped that if all the programmes identified are implemented successfully, India would be able to attain self-sufficiency in raw nut production and maintain its supremacy in the international market.

February 2007

(MG BHAT)
Director

EXECUTIVE SUMMARY

This Perspective Plan of National Research Centre for Cashew (NRCC) is prepared to outline the programmes, which should be pursued to sustain the premier position, which India enjoys in cashew production and processing. While drawing the Perspective Plan, the current scenario, research and development trends, production technologies developed over the years and the future demand both in the domestic and international market have been kept in mind. For achieving the research objectives, collaborations and strengthening the research capabilities are outlined. For sustainable production, eco-friendly production technologies are conceived to be developed.

Cashew which was introduced into India has achieved the status of an important horticultural export earning crop in the recent years. The National Research Centre for Cashew is the nodal agency for conducting research at present which also houses the All India Coordinated Research Project on Cashew which has nine centres located in eight cashew growing States in the country. The research achievements of National Research Centre for Cashew and All India Coordinated Research Project on Cashew and their impact has been presented in Chapters 4 and 5. So far 37 varieties have been developed of which 21 have the export grade (W240 and below) kernels.

The standardization of softwood grafting technique in cashew has enabled commercialization of graft production in cashew and increased availability of quality planting material with annual graft production now reaching about 70 lakh during 2005-06. This has enabled to increase area under cashew with recommended varieties both in traditional and non-traditional regions which already has large impact on the increase in production and productivity and also will enable the country to achieve self sufficiency in cashewnut production in next years and beyond.

NRCC has the largest germplasm collection of cashew in the country (NCFGB) with 506 accessions. A total of 433 cashew accessions have been assigned with National Collection numbers. It has released three selections, namely, NRCC Sel-1, NRCC Sel-2 and Bhaskara, of which the last two are high yielding and medium nut types and recommended for cultivation in Karnataka. In micropropagation, regeneration of cashew from the seedling explants (nodal cultures) has been standardized. Micrografting technique for in vitro multiplication of cashew has been standardized and cashew plants raised by micro grafting have been field planted. It has also demonstrated the advantage of growing intercrops like pineapple and turmeric profitably in cashew gardens. Glyricidia grown as intercrop during initial years contributed 5.75 t/ha of dry matter, equal to 186 kg N, 40.8 kg $P_2O_2$and 67.8 kg K_2O/ha. Individual tree terracing with crescent bunding is the best soil and water conservation measure in sloppy lands. High density planting (625plants density/ha) was shown to be better than normal spacing (8m x 8m) resulting in a yield increase by 2.5 times over control in the initial ten years. Irrigating cashew at 60-80 litres of water/ tree once in four days through drip after initiation of

flowering till fruit set and development in combination with the application of 750: 187.5: 187.5 g of NPK/ tree led to significant higher yields. Softwood grafting method has been standardized and its feasibility for the commercial multiplication has been demonstrated and this technique is being commercially utilized for large scale production of planting material in cashew in the country. The rearing technique for cashew stem and root borer (CSRB) on host bark has been standardized. Volatiles and extracts in hexane from both healthy bark and frass on testing by EAG elicit response from adult female beetles of CSRB. Laboratory rearing technique for tea mosquito bug (TMB) has been standardized. Among the new insecticides evaluated against the pest, λ-cyhalothrin was very effective in reducing the damage under field condition. Sweetened and flavoured spread could be prepared from cashew kernel baby bits. Cashew kernel baby bits could be coated with different combination of flavour and colours. Cardamom flavoured and apple green / saffron coloured and sweetened cashew kernel baby bits are most preferred. Sweetened and flavoured cashew kernel baby bits could be stored without quality deterioration for 12 months at ambient temperature. The centre has established very good linkage with farmers and officials of State Departments and Development Agencies.

While considerable progress has been made in the research at NRCC and AICRP on Cashew, low productivity of 670 kg per ha (productivity being 815 kg/ha on productive area basis) is of concern. This is mainly due to unproductive seedling plantations which are established under neglected conditions in Forest, Soil Conservation and Cashew Corporation Plantations. Replanting these areas with new varieties which have competitive edge in the international market is the first priority. Planting material requirement of 10 to 15 million grafts annually is to be met for tasking up such a programme. Standardization of micropropagation from mature tree explants is essential for meeting such a large demand. South-east Asian countries have taken up cashew cultivation in the recent years and are likely to pose a threat to India's share in international market. Therefore, developing eco-friendly cultural practices like organic farming as a component of IPNM and developing pest tolerant varieties, use of botanical pesticides and development of pheromone traps as a part of IPM is essential. The major export from India is only through cashew kernels at present. Value addition and product diversification should also receive adequate attention for having competitive edge and higher returns in the years to come.

To support these research efforts, enlarging genetic variability through introduction of exotic germplasm, basic studies to characterize through molecular markers, physiology of flowering, influence of endogenous hormonal levels on fruit set, plant-water-nutrient interactions, pheromone studies and pesticide residue analysis need strengthening.

Human resource development in the frontier areas of bio-technology, plant hormone studies and sex pheromone studies are contemplated in XI Plan. Scientific posts are needed in discipline of Plant Pathology and Agril. Microbiology and more technical personnel to support scientific activity. Hence provision for posts of scientists

in Plant Pathology, Agril. Statistics and Agril. Microbiology disciplines and more posts of technical personnel will be included in XI Plan proposal. Suitable dwarf and compact cashew varieties with high yield need to be introduced from Brazil, the home of cashew through MOU between India and Brazil for adopting high density planting system in order to increase the productivity of cashew. Competiting crops such as mango and rubber *vis-à-vis* cashew was discussed.

With all the concerted efforts put up by cashew scientists of NRCC and AICRP - Cashew and also of other SAUs and officers of development departments and cashew / forest corporations, India would surely be self sufficient in raw cashewnut production in next 10 years and beyond and meet the full requirement of raw cashewnuts for processing by cashew processing industry in order to supply cashew kernels both for internal consumption and export.

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NRCC – PERSPECTIVE PLAN

1. PREAMBLE

Cashew is one of the important plantation crops introduced into India during the 16th century. The potential of this crop in the international trade was first realized by India in the early 1900s' through the export of cashew kernels. Since cashew was considered as suitable for afforestation and soil conservation purpose, the cashew plantations raised till recently received very little attention. Further, cashew was always planted in the waste land and marginal lands with poor fertility status. Now India has largest area in cashew and it is also the largest producer, consumer and exporter of cashew in the world. Cashew is mostly grown in East Coast and West Coast of India and also in North-Eastern hilly regions to a limited extent. The present cashew area in the country is 8.55 lakh ha. Production during 2005-06 was 5.73 lakh tones. Brazil and Vietnam are the competitors to India for cashew production and export.

However, India needs about 11 – 12 lakh tons of raw cashew nuts per annum for feeding over 1700 cashew processing units. In order to meet the requirement of the processing industry, India imports annually about 5-6 lakh tons of raw cashew nuts from African and other countries. As these countries have started processing their own cashewnuts, the availability of nuts for import may reduce or may stop altogether in future.

At present, area under cashew in the country is about 8.55 lakh hectares. India produces about 60-70 lakh cashew grafts annually through soft-wood grafting technique which has revolutionalized the availability of planting material in cashew in the country . There are about 80 Regional Cashew Nurseries which are coming under both public and private sector. Most of the area under cashew is in east-coast and west-coast regions of the country. However, cashew is being grown to a limited extent in non traditional areas such as Bastar region of Chattisgarh State and also Kolar region of Karnataka state. About 40 thousand hectares of area can be brought under cashew in Chattisgarh state while the present area under cashew is very negligible (about 2813 ha) in that state. In cashew growing states like Karnataka, cashew is fast expanding in non traditional areas.

About 30-35 thousand hectares are brought under cashew every year in the country by planting 60-70 lakh cashew grafts at the rate of 200 plants per hectare. It is expected that the cashew graft production can be increased to 90-100 lakhs per annum in XI Plan period and 150 lakhs in next 10-15 years. Besides increasing area, productivity per unit area also has to be increased in order to make India self-sufficient in production of raw cashew nuts.

India has been exporting cashew kernels since the early part of the 20th century. The country exports annually about cashew kernels in the range or 1.15 to 1.30 lakh tons worth over Rs. 2500/- crores. Cashew kernels are exported from India to more than 65 countries of the world. The largest buyer of Indian cashew kernels are USA and Netherlands.

Cashew kernels are very tasty as well as nutritious. Cashew kernels contain protein (21%), fat (47%)), carbohydrates (22%), minerals and vitamins. Cashew kernel proteins contain all the essential aminio acids. Cashew kernel proteins are comparable with milk protein, casein, in terms of, Protein Efficiency Ratio (PER) which is 3.2. Cashew kernel do not contain any anti-nutritional factors. Cashew kernels contain 47 per cent fat which is quite rich in unsaturated fatty acids. Cashew kernels are free from bad cholesterol and contain sizeable quantity of mono unsaturated fatty acid (oleic acid) which is now believed to be as efficient as poly unsaturated fatty acids in lowering blood cholesterol through enhancing the levels of High Density Lipoprotein (HDL) cholesterol and reducing the levels of Low Density Lipoprotein (LDL) cholesterol. Thus, cashew kernel is most safe food.

With the growing importance in the export trade, research attempts were initiated in the early 1950s' by the Indian Council of Agricultural Research by sanctioning ad-hoc schemes located at Kottarakkara in Kerala, Ullal in Karnataka, Bapatla in Andhra Pradesh, Daregaon in Assam and Vengurla in Maharashtra. Schemes for the above centres were sanctioned during 1952 to 1957. Cashew research under ICAR was given more importance with the establishment of Central Plantation Crops Research Institute (CPCRI) in 1970 with the headquarters at Kasaragod, Kerala. Cashew was also included as one of the mandatory crops of this new institute. At the same time, ICAR also sanctioned the All India Coordinated Spices and Cashewnut Improvement Project (AICS and CIP) in 1971 with its headquarters at CPCRI Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to take up cashew research under CPCRI, while the four University Centres (Bapatla, Vridhachalam, Anakkayam, later shifted to Madakkathara and Vengurle) were given the research component on cashew under AICS and CIP. Subsequently, during the V and VI Plans three more centres were started at Bhubaneswar, Jhargram and Chintamani.

During 1982 cashew research was further strengthened by implementation of World-Bank aided Multi State Cashew Project which had a research component in four states, namely Kerala, Karnataka, Andhra Pradesh and Orissa. This programme was implemented during 1982 to 1986. The Quinquennial Review Team of CPCRI constituted by ICAR in 1982 recommended delinking of cashew and spices research from CPCRI and starting of the National Research Centres for Cashew at Puttur (Karnataka) and for Spices at Calicut (Kerala). At the same time Working Group on Agricultural Research and Education constituted by Planning Commission for VII Plan proposals and also the Task Force on Horticulture of ICAR made similar recommendations. These recommendations

were implemented during the VII Plan period with the sanctioning of two NRCs. At the same time, the ongoing All India Coordinated Spices and Cashewnut Improvement Project was also bifurcated and the headquarters of All India Coordinated Research Project on Cashew was shifted to NRC for Cashew, Puttur. In addition, one more centre under AICRP on Cashew was sanctioned during the VIII Plan in the non-traditional area in Chhattisgarh at Jagdalpur bringing the total number of centres under AICRP on Cashew to eight. This new Centre at Jagadalpur was sanctioned mainly as there is a potential for cashew cultivation in about 50,000 ha in Chhattisgarh. A Sub-Centre was also started under AICRP on Cashew during the VIII Plan in Kerala Agricultural University at Pilicode (Kerala) to cater to the research needs of northern Kerala, which contributes sizable quantity of raw cashew nuts to the total production of the country. However, in 1995 it was decided that the All India Coordinated Research Project on Cashew would also be monitored by the Director of National Research Centre for Cashew (Organogram of cashew research in India is at Annexure-I. Cashew research centres are shown in Annexure-II).

The headquarters of National Research Centre for Cashew is located 5km away from Puttur town (12.45 N latitude and 75.42 E longitude) and is about 90 m above MSL. The main campus at Kemminje, Puttur has an area of 68 ha of land having field experiments and Laboratory-cum-Administrative building.

Besides the main campus at Puttur , an Experimental Station at Shantigodu, which is 13 km away from the main campus also forms part of this Research Centre. This Experimental Station was started as Cashew Seed Farm under CPCRI in the year 1972. In addition to a number of field experiments, Entomology and Soil and Water Conservation laboratories are located at this Experimental Station.

2. VISION

National Research Centre for Cashew was established in 1986 at Puttur after delinking of cashew research component from Central Plantation Crops Research Institute with the main purpose of giving thrust on increasing the production and productivity of cashew in the country. Since then India has progressed substantially in research front in cashew. Now the main vision for cashew is as follows.

- To make National Research Centre for Cashew, a premier internationally recognized institution for cashew Research.
- To make the country self sufficient with respect to raw cashewnut production and to maintain top position in the world as largest producer/processor /exporter.

- To develop technologies to utilize by-products effectively in order to increase the income of cashew farmers.

2.1 Mission

National Research Centre for Cashew was conceived to undertake mission oriented research projects with the mandate of evolving high yielding varieties of cashew with resistance / tolerance to pests such as tea mosquito bug, high protein, lysine and other desirable parameters, standardization of agrotechniques for achieving higher production and productivity with sustainability in view, and transfer of technology to farmers extension agencies on improved production techniques through training, demonstrations and extension literature.

The self sufficiency in cashewnut production in the country can be achieved within about 10 years by resorting to following two strategies:

- Area expansion both in traditional and non-traditional areas.
- Increase in productivity which is possible by developing high yielding dwarf and compact cashew types suitable for high density planting and also by developing other cashew production technologies with farmers and cashew corporation / forest corporations adopting them in their cashew orchards.

2.2 Mandate

Mandate for cashew research as a whole under National Research Centre for Cashew and All India Coordinated Research Project on Cashew is reoriented as under:

- To conduct mission-oriented research on all aspects of cashew for improving productivity and quality with special reference to export.
- To serve as a national repository for cashew germplasm and a clearing house for research information on cashew.
- To act as centre for training in research methodologies and technology updating of cashew and to coordinate national research projects.
- To provide consultancy on cashew production technology.
- To generate quality planting material
- To collaborate with national and international agencies for achieving the mandate.

3. GROWTH

3.1 Infrastructure

3.1.1 Laboratory

Laboratory facilities for conducting research in Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology have been established after the establishment this research centre in 1986. A well equipped laboratory for Micropropagation has been established. Some of equipments procured by this research centre include HPLC, Gas chromotograph, preparative ultracentrifuge electrophoretic unit, spectrophotometer, ADC photosynthetic analyser, atomic absorption spectrophotometer, Kjeltech auto analyser, microscopes with attachment for photomicrography, millipore water system, laminar air flow, BOD incubators, computers, leaf area meter, protein hydrolyzing unit, electrophoretic apparatus, air purifying modules, gel documentation system (alpha imager), microfuge, deep freezer (-87°C), master gradient thermocycler (PCR machine), growth chambers etc.

3.1.2 Library

The centre has got well-established library in the field of cashew research. The library is serving as an information centre on all aspects of cashew research and development in the country. The CD database viz., CABHORT, CABPEST, AGRICOLA, AGRIS, SOIL CD, CROP CD, PLANTGENE CD are also available in the library. The library also has library automation software and bar- coding facility. There is inter-institutional Library Sharing arrangement with CPCRI,Kasaragod and IISR, Calicut.

3.1.3 Field

The main campus at Kemminje, Puttur has an area of 68 ha with field experiments and Laboratory-cum-Administrative Building. While establishing this Research Centre, the cashew seed farm at Shantigodu established earlier by CPCRI Kasaragod, with an area of 80 ha was transferred to NRCC and now forms the Experimental Station of this Research Centre. Field experiments have been planted at Shantigodu also. Shantigodu is 13 KMs away from this main campus.

3.1.4 Building

Since the starting of this research centre in 1986, laboratory-cum-Administrative Building, 36 residential quarters, Extension of laboratory building housing Biotechnology, Biocontrol and Post-Harvest Technology Units, Fertilizer godown, Farm complex consisting of Farm office, Rest room and a Store room, Generator shed, Maintenance Unit building, Propagation shed, Insectary, Insect net house, Green house, Soil and leaf analysis laboratory etc. have been constructed. The centre also has got a Trainees hostel-cum-guest house. The construction of Library-cum-conference hall complex is already completed (only fixing of AC units to library is pending). Construction of Engineering Workshop cum Field Laboratory and 450 metre length of compound wall will be completed soon.

3.1.5 Computer facility

The Research Centre has Agricultural Research Information System Cell (ARIS Cell) with a few computers and Internet facility. Further, different sections also have been provided with personal computers connected with LAN.

3.2 Budget (Rs. in lakhs)

Plan period	Plan	Non-Plan	Total
VII Plan	109.85	66.49	176.34
Annual Plans 1990-01 and 1991-92	93.58	56.69	150.27
VIII Plan	380.56	189.63	570.19
IX Plan	388.51	480.70	869.21
X Plan	568.00	895.00	1463.00

Manpower (Sanctioned)

Plan period	Scientific	Technical	Administrative	Auxillary
VII Plan	21	14	8	3
1990-01 and 1991-92				
VIII Plan	16	22	15	Nil
IX Plan	16*	26**	15**	Nil
X Plan	18* (11)	23 (19)**	15 (14)**	Nil

* Excluding Director

** 4 posts under Technical Category and 1 post of Hindi Typist cum Translator sanctioned in IX Plan and reiterated in X Plan are yet to be created by ICAR for creation.
Figures in parentheses indicate staff in position as on 31-3-2006

4. SALIENT RESEARCH ACHIEVEMENTS

4.1 Genetic Resources / Crop Improvement

4.1.1 Establishment of gene bank

The National Research Centre for Cashew (NRCC), Puttur (Karnataka) which was established in 1986 was given priority programme of establishing National Cashew Field Gene Bank (NCFGB) and also a mandate to collect and conserve the available germplasm. So far, a total of 506 clonal accessions have been collected and conserved in NCFGB. Characterisation of cashew germplasm after six harvests has been taken up at NRCC using the "Cashew Descriptors" suggested by IPGRI, Rome. The first set of 56 accessions planted in 1986 were characterised and published in the "Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-I", 1997. The second set of 97 accessions planted in 1987 and 1988 were characterised and documented in the "Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-II", 1998. The third set of 102 accessions planted in 1989 and 1990 were characterised and documented in the "Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-III", 2000.

National / Indigenous collection numbers (IC Nos.) have already been allotted by NBPGR, New Delhi for 433 cashew accessions that are conserved in NCFGB and 716 cashew accessions that are conserved in Regional Cashew Field Gene Banks (RCFGB) at AICRP-C Centres. The NCFGB accessions include primary collections from Karnataka, Andhra Pradesh, Tamil Nadu, Goa, Maharashtra, Orissa and West Bengal. Besides these accessions, the gene bank includes diverse accessions selected for big apple (> 150g) and medium nut size (6.4-8.7g), bushy and compact canopy, cluster bearing habit and early bearing, from the germplasm at Vittal and Shantigodu. Besides the indigenous collections, few exotic collections raised from seednuts from Brazil and Mozambique are also conserved in NCFGB. Nine cashew germplasm accessions of NCFGB have been registered for possessing distinct characters under Plant Genetic Resources Registration of NBPGR. District-wise cashew germplasm collection maps have been prepared for 1167 accessions. A technical bulletin on "Status of Cashew Germplasm Collection in India" covering 1167 cashew accessions conserved in the country upto 2001 has been published in 2002.

4.1.2 Varieties Released

Based on the performance, two accessions (VTH 107/3-1 and VTH 40/1-1) were released as varieties NRCC Selection-1 and NRCC Selection-2 respectively during IX Biennial Workshop of All India Coordinated Research Project on Cashew held at Tamil Nadu Agricultural University, Coimbatore, in October 1989. These selections have a yield range of 8-10 kg/tree/year, and nuts are medium to bold (7.6 to 9.2g). These

selections have a shelling percentage of 29 per cent. Recently, another high yielding variety namely “Bhaskara” has been released to coastal region of Karnataka.

4.1.3 Varietal Improvement of Cashew

Systematic efforts are underway for improving the varieties released and to characterise them for various physiological and other growth characters. Mixed flowering phase was present in all the released varieties studied and was of longer duration than the male phase. Fruiting intensity and yield per square metre canopy were found to be most important yield component characters based on correlation and regression analysis studies. The varieties were found to vary for the primegenic dominance character (the phenomenon of first formed fruits reducing the chances of fruit set from later opened flowers). A total of 36 released varieties were studied for status of adherence of testa to the kernels, which is an important character affecting processing efficiency. The varieties were grouped into loose, medium or tight adherence category based on the strokes required for removing testa from kernels. NRCC Sel-1 variety was found to have loose testa adherence.

Large number of hybrids have been evaluated and Hybrid 46 (BPP 6 x A 18/4) and H 32/4 (BPP 5 x VRI 1) were found promising and they are under field-testing / on-farm trial in the plots of Puttur Division of Karnataka Cashew Development Corporation and demonstration farmers. Large number of hybrids made between released varieties (high yielding but with small to medium nut size) and bold nut types under nut size improvement programme are under evaluation. Three hybrids namely H-1250, H-1205 and H-1273 were promising with cumulative yield of 22.57, 19.71 and 18.75 kg/tree respectively for nine harvests. Large number of hybrids have been made by crossing diverse parents and field planted under ICAR Ad-hoc Scheme on “Network Programme on Hybridization in Cashew”.

Hybrids of several cross combinations were evaluated in hybrid -graft trial at Shantigodu campus and a few hybrids appear to be promising for yield and nut character from the second year of yielding itself. Among them H-66, H-68 and H-43 (all are cross combinations of NRCC Sel-2 x Bhutnath-II) and hybrids H-125 and H-120 (both NRCC Sel-2 x Bhedasi). All the hybrids had more than 10 g nut weight and cumulative yield above 6 kg/tree for 2 harvests.

4.1.4 Micropropagation

A project was initiated in 1990 with an objective of undertaking micropropagation of cashew elite lines and to exploit somaclonal variation. Multiple shoot induction was observed in cotyledonary nodes and in nodal cultures of seedling origin on modified MS medium supplemented with thidiazuron (0.1 to 0.5 mg/l). In vitro and ex vitro rooting has been achieved. Plantlets have been transferred to pots and acclimatised under laboratory condition. Twenty nine plants raised by nodal cultures have been field

planted in 1997 and 60 plants have been field planted in 1999 along with grafts as control at 5m x 5m spacing and are being evaluated. Micropropagated plants showed 100% establishment, better vigour and growth than grafts. Micrografting technique has been standardised using *in vitro* raised seedling as rootstock and aseptic nodal/shoot tip cultures from mature tree source as micro scion. The micrografts have been successfully hardened and established in pots. Four species of native VAM has been inoculated from the cashew soil and the predominant species *Scutellospora nigra* have been used for acclimatisation of micro propagated plants. Somatic embryogenesis has been observed in immature cotyledon cultures on MS supplemented with 2,4-D, BA, NAA and coconut water. Somatic embryogenesis has also been induced in nucellar callus. Somatic embryos were matured and germinated successfully in two varieties.

4.1.5 Finger printing of cashew using DNA and isozyme markers

DNA extraction from cashew leaves was standardized. DNA was extracted from 205 accessions of cashew. Molecular characterization of released varieties was done using both RAPD and isozyme markers. Species and interspecific hybrids were also similarly characterized using 11 primers of RAPD and isozyme pattern of 6 enzymes. Work on ISSR and SSR markers has been initiated.

Isozymes were extracted from fresh young leaves. Esterase, glucose phosphate isomerase (GPI) phospho glucomutase (PGM), superoxide dismutase (SOD) and acid phosphatase (ACP) alone gave clear bands. Isozyme profiles generated for four species. (*A. occidentale, A. pumilum, A. orthonianum, A. microcarpum* and purple plant genotype) showed that esterase, GPI, PGM isozyme pattern were polymorphic between the species. GPI and esterase profiles studied for 21 varieties showed that esterase pattern was polymorphic between the varieties whereas, GPI pattern was monorphic between the varieties.

4.1.6 Biochemical Characterisation of Released Varieties

Cashew kernel, testa, shell, and apples from released varieties of cashew have been characterised for their biochemical composition. Released varieties exhibit wide variation with respect to kernel oil, protein, starch and sugar content. Kernel protein content among different varieties varied from 35.6 to 65.8%. Sugar content showed variation from 6.9 to 20.6%. Oil content among different varieties varied from 35.3 to 47.4%.

Cashew kernel testa, apart from containing tannin, is quite rich in protein, starch and sugar and varietal variation has been noticed. Protein in tannins free testa from different released varieties varied from 25.97 to 69.38%. Sugar content in the testa varied from 180 µg/100 mg to 640 µg/100 mg. Tannin in the whole testa among different varieties varied from 45 to 93%. Cashew shell after removal of CNSL by

solvent extraction contains considerable quantity of protein, sugar and starch.

Cashew apple juice from released varieties have been characterised for biochemical composition and organoleptic acceptability. Among the varieties evaluated so far, BPP-4 and Jhargram-1 have low tannin (1 to 3 mg/ml), high sugar (70 to 100 mg/ml), high ascorbic acid (2 to 5 mg/ml) and MCH of 13 to 17, which is desirable for developing cashew apple based products.

4.2 Crop Management

4.2.1 Varietal Response to Graded Doses of N

In an experiment on the response of eight high yielding varieties to graded doses of N, the mean yield of nuts increased with increased level of N. Highest yield was recorded at the fertilizer dose of 750 g N/tree/year.

4.2.2 Integrated nutrient management

Nutritional studies have indicated that combination of inorganic fertilizers (500 g N and 125 g each of P_2O_5 and K_2O) and 10 kg poultry manure/tree is beneficial in getting higher yield under unirrigated condition. The yield obtained was 235 per cent of control where no organic manure and inorganic fertilizers were applied. In high density planting situations (625 trees/ha) one third of recommended doses (250 g N, 50 g P_2O_5 and 50 g K_2O/tree/year) of fertilizers was sufficient to nutrient for the first ten years.

Terrace (2 M radius) with crescent bund (6 M length, 1 M width at the base of ½ M height towards upper side of the slope at the end of terrace and application of 20 kg poultry manure/tree gave best result in terms of moisture retention in soil and also nut yield/tree. Terrace with crescent bund alone with poultry manure resulted in increase in yield (188 to 227%) reduced peak run off (10%) and soil loss (50%) compared to control.

4.2.3 Irrigation

Results from an observational trial on the effect of irrigation on cashew have indicated definite response of cashew for supplementary irrigation of 200 litres of water at fortnightly intervals between January and March. Based on these results, a new trial on micro irrigation with graded doses of NPK was laid out in 1989 to assess the efficacy of micro-irrigation on the productivity of cashew grafts. Among the different treatments of irrigation nut yield in the case of I_4 (three drippers with 5 litres/h discharge, 60 litres/tree) and I_5 (four drippers with 5 litres/h discharge, 80 litres/tree) was highest

compared to I2 (two drippers with 2.5 litres/h discharge, 20 litres/tree) and I3 (two drippers with 5 litres/h discharge, 40 litres/tree) for the first eight years. Application of higher dose of NPK (750 g N, 187.5 g P_2O_5, and 187.5 g K_2O/tree/year) coupled with irrigation of 80 litres/tree once in four days through drip irrigation from December 15th to March end resulted in increased cumulative yield of cashew for first 8 years by 135% compared to control plot receiving neither irrigation nor fertilizer.

In high density planting situations application of inorganic fertilizers through fertigation and soil application of organic manure is beneficial in achieving highest yield and profit. Application of 50% of recommended doses of inorganic manure (125 g N, 63 g P_2O_5 and 63 g K_2O/tree/year) through fertigation and remaining 50% applied in the form of organic manure (cashew cake 1.5 kg/tree) fetched highest yield (2 t/ha) and profit/ha.

4.2.4 Cropping System

In order to enhance the returns during initial years of cashew plantation, trials have been laid out with various fruit crops, food crops and forest species. Among the fruit crops, growing pineapple was found to be most profitable. Forest species (acacia, subabul and casuarina) were also tried as intercrops. Though growing casuarina fetched maximum profit, growth of the main crop was affected. Among the annual crops turmeric can be grown as intercrop in cashew garden for the first 5 years. A profit of Rs. 38,000/ha can be achieved from turmeric only as intercrops. Growing turmeric has no deleterious effect on maincrop (cashew).

4.2.5 High Density Planting

In order to optimise the plant density in cashew, trials with different density and spacing in cashew were initiated. Maintaining the plant density of 625 trees/ha at a spacing of 4m x 4m upto 12th year was shown to be highly profitable (Rs. 70,054/ha for first 12 years). Under normal (156 trees/ha) tree density profit was only Rs. 26,200/ha. Subsequent trials on high density planting in cashew with grafts has indicated increased soil moisture content at lower depths during peak summer, increased organic matter content, reduced evaporation of water from ground and reduced soil temperature. Net profit realised from high tree density planting (384 trees/ha, 6.5 x 4m) was Rs. 73,735/ha for first 10 years. Under normal tree density (156 trees/ha) net profit realised was Rs. 30,151/ha.

4.2.6 Organically recyclable biomass for integrated nutrient management

The green manure crop Glyricidia grown as intercrop contributed highest quantity of nutrients, which is equal to 186 kg N, 40.8 kg P_2O_5 and 67.8 kg K_2O/ha at NRCC, Puttur. The cashew plots which received Biofertilizer-Azospirillum with

compost of organically recyclable biomass available in cashew garden recorded highest yield (1053 kg/ha) and profit (Rs. 28,601) followed by the plots which received 50 and 75 % N of recommended dose of nutrients applied in inorganic form and remaining applied in the form of composted organically recyclable biomass.

4.2.7 Preparation of compost from recyclable cashew biomass

Cashew leaf litter, apple and weed growth (recyclable biomass) can be utilized for the preparation of compost rich in nutrients like nitrogen (1.6%), phosphorus (0.55%), potassium (0.1%), magnesium (0.2%), calcium (27 ppm), manganese (75 ppm) and iron (1.5 ppm) within 6 months. The compost will also be rich in beneficial bacteria, fungi and actinomycetes.

4.2.8 Preparation of vermicompost

The cashew biomass fallout from cashew garden when treated with cow dung slurry (15% of total weight) could be converted into vermicompost within three months by earthworm (*Eudrilus* sp). Organically recyclable biomass (2 tons) could be converted into 1.3 ton of vermicompost with net recovery of 65 %. Vermicompost thus produced was rich in Organic Carbon (11.91%), N (1.2%), P (0.9%), K (0.6%), Ca (2.75%), Mg (0.80%) and micronutrients like Fe (162 ppm), Mn (24.5 ppm), Cu (12.4 ppm) and Zn (29.7 ppm)

4.2.9 Pruning

Effect of pruning on the cashew yield was investigated and the results indicated that pruning of leader shoot in July and August doubled the yield over control. In continuation of this trial, a large plot trial was undertaken to demonstrate the beneficial effects of pruning. Leader shoot pruning in the month of August proved to be beneficial with a two-fold increase in yield. Even in the "on farm" trial at KCDC Plantation, Kunthur, pruning has resulted in increased yield.

4.2.10 Canopy redevelopment

Beheading (de-crowning) the exhausted canopies of low nut yielding trees to rejuvenate the growth was most promising in enhancing performance of the trees and thereby nut yield. Beheaded trees redeveloped canopies in a short span of time 5-6 months, flowered and fruited in the same year in varieties like Ullal-1 and VRI-1 among the test varieties. In vigorously growing types the vegetative growth dominates for a year or so, and nut yield is very low.

4.2.11 Induction of Dwarfing

Trials have been initiated to induce dwarfing through chemical intervention particularly paclobutrazol which has been extensively used in containing the canopy growth of mango. Soil application of paclobutrazol at 8 g ai/plant at preflushing stage (September) was found to be effective in regulating the tree and canopy growth in cashew.

4.2.12 Propagation Studies in Cashew

Softwood grafting technique is the best method for commercial multiplication of cashew varieties. The best period for grafting was found to be June to October with a graft success of more than 70 per cent. Graft success has been correlated with weather parameters. Root stocks of VTH 174, NRCC Selection-1 and V-1 varieties were found to be ideal as nuts are medium sized and produce vigorous seedlings, required for soft wood grafting within 60 days of sowing of seeds.

4.2.13 Off-Season Grafting

Studies on off-season grafting have indicated that off - season grafting is possible during flushing season with green scion sticks. In case of softwood grafting, green scion sticks of more than 30 days old gave about 60 per cent sprouting during October-November. Studies using low cost humidity chamber have indicated that the per cent success of softwood grafts prepared was comparable with the grafts enclosed with individual caps as control.

4.2.14 Top Working

Studies on top working of cashew have revealed that the technique could be employed successfully for rejuvenating cashew trees under homestead gardens if infestation by Cashew Stem and Root Borer (CSRB) is carefully controlled after top working. This technique has been shown to be best suited for trees of less than 10 to 15 years old. On a large scale, this technique cannot be adopted because of very high mortality due to CSRB infestation. Higher mortality of top worked trees has been observed wherever prevalence of CSRB is high.

4.3 Crop Protection

Cashew stem and root borers (CSRB) and tea mosquito bug (TMB) are the major pests of cashew leading to economic loss. Trials have been conducted to evolve suitable management practices against these pests.

4.3.1 Cashew Stem and Root Bore r (CSRB)

Phytosanitation was found to be an important aspect to minimize CSRB infestation in cashew. Removal of dead trees, trees with yellow canopy and / or more than 50% bark circumference damage which serve as natural inoculum repositories for further spread of the pest was found essential. The percentage of trees with fresh incidence, mean number of CSRB grubs encountered per infested tree reduced significantly in trials at NRCC. A maximum cost-benefit ratio of 1:1.8 was achievable due to phytosanitation in comparison to non-phytosanitation.

A method for estimating age of the grubs of CSRB in the field was evolved by measuring prothoracic shield width (PTS). This method helped in finding out the maximum egg laying period and the time for initiation of plant protection measures. The egg laying was maximum during February – May coinciding with nut collection period and so farmers can give more attention for taking up timely plant protection measures against this pest.

Post treatment prophylaxis was effective is saving the trees at initial stages of infestation. The eggs, grubs and pupae present inside the bark and root should be removed by careful chipping off the bark. Chlorpyriphos (0.2%) led to highest percentage of trees without reinfestation followed by monocrotophos (0.2%) and lindane (0.2%). Treated trees in initial or moderate stages of attack showed highest recovery.

The fungal pathogen *Beauveria bassiana* was found to be effective in inducing mortality in CSRB grubs. A field isolate of *Metarhizium anisopliae* was also effective in causing mycosis in grubs. Spores of *M. anisopliae* survives for maximum of three months under field condition.

Mass rearing technique for collection of different stages of CSRB for experimental purpose has been standardised. Stout cashew twigs wrapped with cotton tape helped in easy egg collection without any physical damage to the eggs. Grubs rearing was done on host bark. Techniques were standardised also for pupal holding and adult rearing.

Under studies on kairomones unmated male beetles and virgin female beetles displayed maximum response to test samples viz., extracts and volatiles of healthy bark, fresh frass and exuded gum in n-hexane Under trials on sex pheromones response by virgin female beetles was the highest to all body extracts (abdominal tip, thorax, base of elytra) followed by mated females. Maximum adults emerge only during a short period (February-May). Use of insect traps based on kairomones or pheromones during this emergence period can help in catching local pest population as well as predicting the initiation of pest attack.

4.3.2 Tea Mosquito Bug

Survey of natural enemies of tea mosquito revealed the occurrence of three species of egg parasitoids (*Telenomus* sp, *Chaetostricha* sp. and *Erythmelus helopeltidis*). Activity of *Telenomus* sp. was noticed throughout the year. It was also collected from insecticide sprayed plantations.

Considering the residual action of various insecticides, monocrotophos (0.05%), λ-cyhalothrin (0.003%) and carbaryl (0.1%) were found to be suitable for the management of TMB. As the TMB incidence coincides with flushing, flowering and fruit set, spray schedule mentioned below is to be followed whenever needed.

At flushing	-	Monocrotophos (0.05%) or λ-cyhalothrin (0.003%)
At flowering	-	Carbaryl (0.1%) or λ-cyhalothrin (0.003%)
At fruiting	-	Carbaryl (0.1%)

A mass rearing technique for TMB has been standardised under laboratory condition using tender shoots of cashew. The technique was very useful for obtaining nymphs and adults required for experimental purpose.

All the released varieties and germplasm accessions screened were susceptible to TMB. An accession Goa 11/6 escapes from the severity of the pest damage due to extended flowering habit. It is being evaluated under unsprayed conditions since 14 years and is performing well as far as yield is considered with more than 2 t/ha.

4.4 Post-Harvest Technology

4.4.1 Quality Evaluation

Results from the concluded project on quality evaluation in cashew have revealed that considerable variation exists among different varieties with respect to the biochemical composition of nuts and apples. Cashew kernel lipids are rich in neutral lipids (96%). Glycolipids and phospholipids constitute the rest (2% each). Triglycerides are rich in unsaturated fatty acids. Based on these results, an index for quality evaluation has been arrived.

4.4.2 Storage Studies

Biochemical changes in the kernel during storage of raw nuts at ambient temperature were studied. Starch and sugar contents tend to decrease with storage time at both ambient and low temperature (6-10°C). Storage of nuts both at ambient and low temperature did not affect the relative distribution of three fractions of kernel storage

proteins such as albumins, globulins and glutelins. Similarly storage of bulk nuts resulted in decreased kernel, starch, sugars and Cashewnut shell liquid (CNSL) content. Raw nuts could be stored for over one year without affecting neither the processing nor biochemical quality.

4.4.3 Factors Influencing Kernel Rejects

Studies on identification of factors influencing the kernel rejects have indicated that processing of immature nuts and floaters resulted in increased per cent kernel rejects with decreased shelling percentage, peeling outturn and per cent wholes recovered.

4.4.4 Value Addition in Cashew

It has been shown that milk and spread could be prepared from cashew kernel baby bits. Sweetened milk flavoured with cocoa could be prepared. Sweetened and flavoured cashew spread could be prepared from cashew kernel baby bits. Cardamom flavoured spread is most preferred. Studies on coating of baby bits have indicated that ideal condition for coating of baby bits with cane sugar is 70% concentration at 100°C. It has been shown that organoleptically acceptable defatted cashew kernel baby bits could be prepared, which could cater the needs of calorie conscious consumers. Permitted colours (apple green, chocolate brown, kesari, lemon yellow, orange red and raspberry red) with different flavours (vanillin, cardamom, ginger and clove) could be coated along with cane sugar. Cashew kernel baby bits could be coated with combination of different colours and flavours. Irrespective of flavour, raspberry coated baby bits are least preferred while apple green and cardamom coated baby bits are most preferred.

4.4.5 Cashew apple pomace utilization

Cashew apple pomace, which is rich in fibre could be blended with cereals (ragi, rice, wheat) and pulses (green gram) upto 10% without affecting the quality in terms of *in vitro* digestibility of both proteins and carbohydrates. Cashew apple pomace based blends could be stored upto 1 year without affecting the quality.

4.4.6 Mineral composition

Studies on mineral composition have indicated that cashew kernels are rich in P and K and considerable variation is exhibited among released varieties. Similarly, cashew apple pomace of released varieties have been analysed for mineral composition.

4.4.7 Nutraceuticals from cashew apple

Studies have been initiated to isolate the nutraceuticals from cashew apple which have industrial application and are also important in human nutrition. Antioxidant activity in methanol extract and different fractions obtained after treatment with ion exchange resins exhibited variation with respect to varieties. Treatment of cashew apple with sodium chloride (2%) and Potassium metabisulphate followed by autoclaving and drying improved the quality of cashew apple powder in terms of lower tannin content.

4.4.8 Establishment of Database on cashew processing industries

Database on processing aspects of cashew processing industries has been established. Data base includes details on prevailing processing aspects, system of storage and personal hygiene.

4.4.9 Modification of Cashewnut Sheller

The existing cashewnut sheller has been modified by introducing cam arrangement which would help the operator to feed the raw nuts with both the hands. Performance of the modified sheller had been evaluated and has been found to be better than the conventional cashew sheller. Patent application has been filed.

4.4.10 On-farm cashewnut processing

The small scale cashewnut processing units which are in operation at Sindhudurg district of Maharashtra were evaluated for their performance and ideal conditions for getting better quality kernel output have been worked out. Pilot plant facilities of farm level processing has been established.

4.5 Transfer of Technology

4.5.1 Production of planting materials

This Research Centre has been producing and distributing the softwood grafts of different released varieties to farmers and other developmental agencies such as Forest Corporation and State Departments of Horticulture. The number of softwood grafts produced and distributed since the standardisation of softwood grafting technique for commercial multiplication is over 13 lakhs.

4.5.2 Training

This Research Centre has been extending support to developmental agencies and departments of horticulture by conducting training programmes regularly. Every year, training programmes on "Vegetative Propagation of Cashew" and "Cashew Production Technology" are being conducted. A considerable number of farmers and personnel from developmental and government agencies participated in these training programmes conducted during the last 15 years. Besides the above training programmes, a delegation of five members from Vietnam was trained for a week between 24th and 31st October 1988 on Cashew Production and Processing aspects of cashew. A trainee from Vietnam underwent training for six months on various aspects of cashew cultivation. Recently the centre has started training on “Pruning in Cashew” and “Composting of Cashew Biomass”.

4.5.3 Demonstration Plots

In collaboration with Directorate of Cashew and Cocoa nut Development, Kochi, demonstration plots have been established in Puttur, Belthangady, Buntwal and Sullia taluks of Dakshina Kannada District with an objective of demonstrating the technologies developed at the research centres in the farmers’ field. So far 140 plots have been raised of which 40 plots are mainly to demonstrate the system of high density planting in cashew. The released and promising varieties are being evaluated in these plots. Considering the success of establishment of these plots, DCCD has extended the scheme to centres under State Agricultural Universities.

4.5.4 Campaigns

Since last five years series of campaigns are being conducted in Dakshina Kannada (Karnataka), Kasaragod and Kollam (Kerala) districts to create awareness on the need for soil and water conservation and plant protection measures. These campaigns were conducted in collaboration with SKDRDP, Dharmasthala, KJP foundation, Thiruvananthapuram, Sri Durga Charitable Society, Keyyur and Department of Agriculture , Kerala. The campaigns were aimed at educating farmers on soil and water conservation measures in cashew and explaining the important factors involved in the management of tea mosquito bug and cashew stem and root borers. The techniques were explained to the farmers with the help of charts and specimens specially designed for the purpose. These techniques were also demonstrated in the selected fields for better understandings. The response of farmers was very good for these campaigns and over 2000 farmers participated and got the benefit.

4.5.5 Cashew Field Day

In order to inform the cashew growers about the latest research developments in cashew and to get the feedback from the farmers about the usefulness of the cashew production technologies disseminated, Cashew Field Days / Cashew Day are being organized either at NRCC, Puttur or at the Cashew gardens of progressive cashew growers. The Centre has organized so far nine such programmes for the benefit of cashew growers, in nearly 1250 farmers were benefited.

5. IMPACT ASSESSMENT

Most of the plantations developed in the country from the early part of this century till late 1980s are of seedling origin. Most of the time, bulk seeds were used by the Forest Departments as well as Soil Conservation Departments for raising the plantations. The primary consideration has been to cover the area than the productivity of the crop. This has resulted in today's nonproductive plantations in many of the traditional cashew growing States like Andhra Pradesh, Orissa, Karnataka and Tamil Nadu. Further, these plantations were all totally neglected with no nutrient or plant protection inputs. In many cases, there was considerable mortality of plants resulting in low population per ha as in the case of Forest Department Plantations. Even when the research results were available by late 1970s the impact of these technologies were not apparent as the plantations had crossed the stage for responding to any inputs. Therefore, for realising the impact of these research results, it will be necessary to take up replanting programme in systematic way in the plantations raised with inferior seed sources.

In Maharashtra, the plantations are of recent origin and hence better planting material (grafts) of improved high yielding varieties have gone to field. Even some of them which are of seedling origin were raised with selected seeds of known varieties. The farmers in Maharashtra are also basically more conversant in cultivation of Horticultural crops and the better management adopted by these farmers is apparent in the productivity of over one ton per ha which is now being realised in this State.

In Kerala, cashew is primarily a homestead crop and the yield levels of 900 kg to 1000 kg per ha realised in many plantations mainly due to adoption of at least some of the technologies like green manuring, removal of deadwood, etc. In rest of the cashew growing States the impact of research results and production technologies is less pronounced.

5.1 Growth (Crop/Commodity/Discipline/Area/Science)

The area, production, productivity, import, export and export earnings over the years are given in Annexure -III· Increase in total area and production during last 33 years,

percent distribution of area, and production in different states and increase in export of kernels during last 35 years are depicted in Figs. 1 to 4 respectively. From 0.11 million ha in 1955-56, today the area has increased to 0.855 million ha. However, the productivity with around 700kg per ha is almost stagnant till 1960s and there was reduction subsequently. This is mainly due the reasons which have been mentioned earlier like raising seedling progeny, non adoption of agrotechnique which are essential for higher production. However, reduction which is noticed in the productivity till 1970s mainly due to the decrease in yields in the seedlings plantations planted in the early 1950s and 1960s which were grown under neglected conditions. During the past few years there has been considerable improvement in the plantations which were established during 1980s and 1990s. It is an opportune time to propagate those varieties with the export grade kernels and distribute to the farmers. Productivity in the state of Maharashtra has already reached one tonne per ha which is the national target. The National Commission on Agriculture has estimated that it should be possible to produce 0.7 million ton of raw nuts from 0.35 million ha. However, while formulating VIII Plan proposals considering the present trends and inputs which cashew received made us to revise the target to one ton per ha which is achievable soon. In the state like Maharashtra the yields are already over one ton and even in the West Coast in the high rainfall area of Kerala 900 to 1000 kgs of raw nuts are being harvested per ha in many plantations. With the available raising trends prevailing at present, it should be possible for us to convince the farmers on the adoption of improved technologies in future in the area which are being brought under cultivation. It is possible to increase the present acreage of 0.855 million ha. to around 0.9 to 1.0 million ha by 2010. This may be sufficient to produce at least 0.9 to 1 million ton of raw nuts in 2010, if all the future plantings are done with the package responsive high yielding vegetatively propagated planting material.

5.2 Input/Output Assessment

The input for the research on cashew can be considered to be less than any other horticultural crop. Eventhough, the research was initiated in 1950s, the funding was minimum till about 1970. Even in the subsequent years after the research mandate has been given to CPCRI, in the Fourth, Fifth and Sixth Plan periods, both under CPCRI as well as under All India Coordinated Spices and Cashewnut Improvement Project, the resources allocated were marginal. Only in the Seventh and Eighth plans, substantial allocations have been made for the research on cashew. In the combined Project of All India Coordinated Spices and Cashewnut Improvement Project, there were only four centres namely Bapatla, Vengurla, Vridhachalam and Anakkayam/Madakkathara (which were established in 1950s) had regular staff and adequate infrastructure. The centres started during the Fifth and Sixth Plan periods, namely, Bhubaneswar, Jhargram and Chintamani could develop the infrastructure and layout the field experiments only during later part of Fifth plan and Sixth Plan periods. Adequate support for the research on cashew was made available during the Seventh Plan period with the

establishment of National Research Centre for Cashew and sanctioning of an independent project namely the All India Coordinated Research Project on Cashew. However, development of infrastructure for research at NRCC took some time and by 1991 the laboratories could be established and most of the land acquisition completed for laying out the field experiments.

Considering the infrastructure available till recently for cashew the research output can be assessed as satisfactory. Altogether 37 varieties could be released for cultivation in different cashew growing States. Various crop production technologies developed, namely, fertilizer doses for different soil types, fertilizer application methods, plant protection schedules did benefit the cashew farmers. It has been possible to formulate a comprehensive cashew production technology based on the results from various research centres. One area where the output has made tremendous impact is the planting material generation. Standardisation of softwood grafting brought revolution in availability of elite planting material. Over sixty lakhs grafts are being annually produced in the country which will definitely contribute to substantial increase in production.

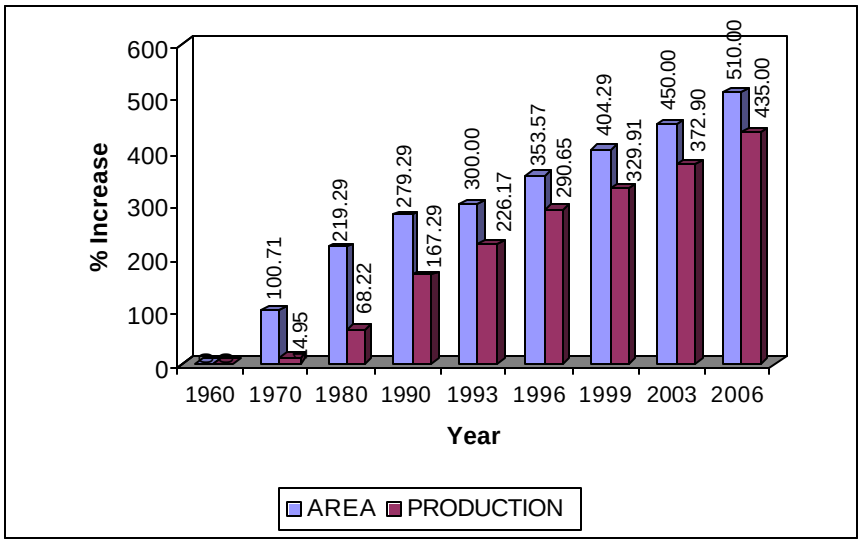


Fig.1: Per cent increase in area and production for the last 45 years

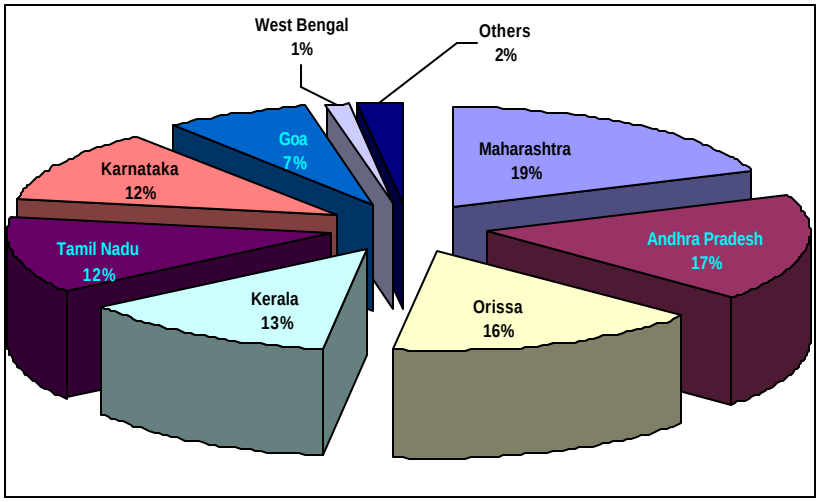


Fig.2: Per cent distribution of area in different states

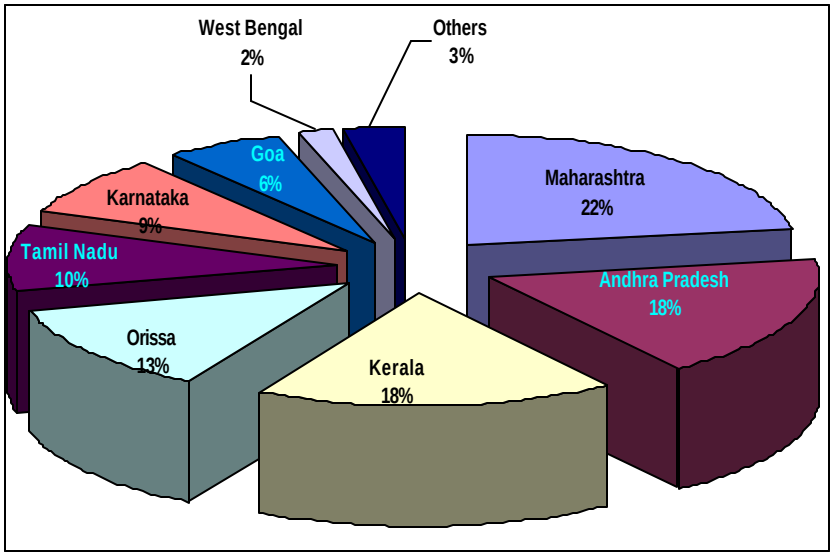


Fig.3: Per cent distribution of production in different states

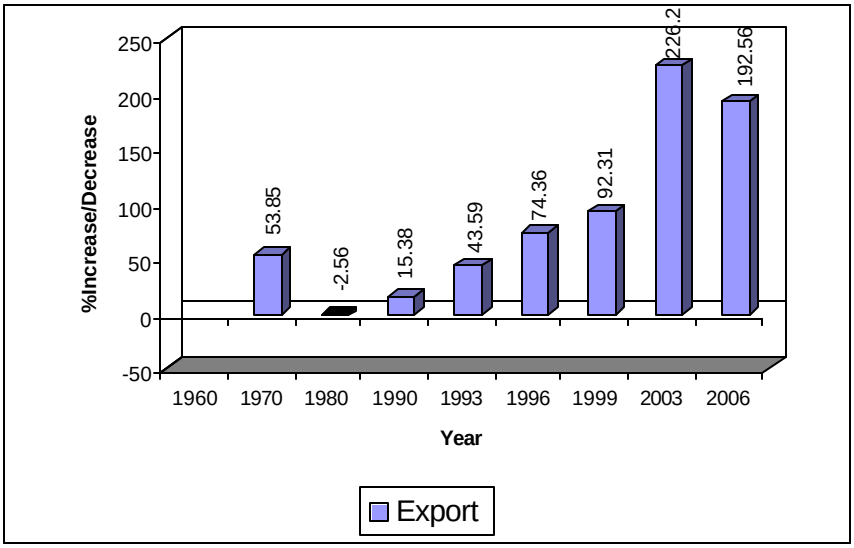


Fig.4: Per cent increase/Decrease in export of Kernel for last 45 years

5.3 Shortcomings

As mentioned in the introduction, cashew research was initiated through ad-hoc schemes in different states which concentrated mainly on collection of germplasm and selection of high yielding trees for propagation. As cashew is a cross pollinated crop, the initial research efforts of identification of mother trees and their multiplication through seeds is one of the causes responsible for the poor yield in plantations established by Forest Departments and Cash ew Development Corporations as well as by small farmers.

There was very little concern for the nutritional aspect in the initial research efforts. As it is considered mostly as a crop which can withstand neglected conditions, none of the plantations established earlier received fertilizer input. Even in research, the nutritional aspect received attention only after the establishment of CPCRI and All India Coordinated Spices and Cashew Improvement Project in 1970 and 1971 respectively. Results of which were available only in late 1970s and even then, the transfer of technology was not effective for convincing the farmers for going in for fertilizer application for enhanced productivity.

Cashew crop luckily does not have any major disease problem, however, tea mosquito and stem and root borer are the two major insect pests which are the limiting factors for production. The yield loss due to tea mosquito bug infestation ranged between 30 and 50 per cent in different years, while the stem and root borer infestation in neglected plantations will be around 8 to 10 per cent. The

recommendations for the control of tea mosquito bug infestation both by traditional ground spray as well as aerial spraying for large plantations were standardized in late 1970s. However, even these plant protection measures are being adopted only in the recent years. This aspect should receive highest attention in the development programmes.

5.4 Lessons Learnt, Suggestion and Options for the Future

5.4.1 Lessons learnt

One of the important lessons learnt in both research and development front is to dispense using seedling progenies for raising cashew orchards. It has been possible over the years to develop the varietal concept in cashew. Another important feed-back is on the need for standards for release of varieties in a perennial horticultural crop. Once the orchard is raised, it is difficult to convince the farmers to replant it with better varieties or a newer clones. Therefore, while recommending the varieties care should be exercised to see that the produce from such varieties will have adequate market potential. In cashew, in the earlier years, while releasing the varieties only high yielding potential of mother tree was taken into consideration, while the kernel grade and the quality was not given adequate attention. This has resulted in release of some of the varieties with very low grade kernels (W-320 and W-400) for cultivation in different States. As these being the first varieties, many farmers seeing high yielding potential did raise the orchards with these varieties. To be competitive in the international market, due attention is to be given for the grade of kernels.

As cashew is a hardy plant, often it has been thought to be highly suitable for afforestation, soil conservation and waste land development. Unfortunately, the plantations raised with this objective, did not receive any management nor inputs, thereby resulting in very low production and productivity. It will be necessary to see that a horticultural crop with export potential is not relegated for such programmes.

5.4.2 Suggestions and options

To some extent, it has been possible to dispense with raising the plantations with seedling progenies. The research centres have standardised vegetative propagation of cashew through soft wood grafting and it has been proved to be commercially viable proposition. Today in most of the States, Regional Nurseries have been established with the support from Directorate of Cashewnut Development and it should be possible for us to raise the future plantations only with the grafts of recommended varieties. The National Research Centre for Cashew and the coordinating centres of All India Coordinated Research Project on Cashew have established bud wood orchards/scion banks and we should be able to make available adequate grafts for establishing scion banks by the development departments for further multiplication and supply to the farmers.

Eventhough, 37 varieties (including five varieties released by ARS, Ullal) have been released so far, based on the review of Planting Material Generation in Plantation Crops in 1989, only 24 varieties have been recommended for multiplication. All these 24 varieties have the yield potential of one ton per ha and also have the export grade kernels of W-240 or better. While identifying these varieties the revised target of one ton per ha fixed by the Working Group constituted for formulating the VIII Plan proposals was kept in mind. However, if we have to achieve self-sufficiency of raw nuts to meet the processing capacity of around 1.0 million ton established in the country, it will be judicious on our part to reconsider revising the target to 2 ton per ha so that only such varieties which have 2 ton/ha yield potential will be released in future.

While taking up replanting of unproductive forest and soil conservation plantations, it would be better to adopt high density planting of 625 plants per ha which was proved to be beneficial in realising higher yields upto 12th year. This will enable the country to achieve self sufficiency of raw nuts in the shortest possible time.

6. SCENARIO (NATIONAL VIS-A-VIS INTERNATIONAL)

India and Brazil are the largest producers of cashew in the world. Brazil has registered an increase of 98 per cent over the last 20 years. Similarly, increase in the raw nut production in India accounts to 128 per cent. Steady growth rate in production of raw nuts in South-East Asian, particularly Vietnam is of serious concern to India. Vietnam has registered an increase of over 1000 per cent in the production of raw nuts. Even China (main land) has registered considerable increase in the raw nut production (116 per cent over 15 years). The world production of raw nuts for the last 20 years has increased from 0.423 million ton (1980) to 2.03 million ton (2003) amounting to 380 per cent. Assuming 20 per cent as outturn, the kernel production in 2003 was 0.406 million ton.

In the international trade, USA is the major consumer of processed kernels. India, Brazil and Vietnam are the major exporters of processed kernels. India's raw nut production is not sufficient to sustain the processing capacity established in the country. To bridge the gap, India has been importing raw nuts from African countries. India has imported 0.453 million ton during the year 2003-04. As many of these African countries have started strengthening their processing capacities, and the increased production of raw nut by South-East Asian countries, it is imperative that India has to increase its raw nut production to sustain itself in the international market.

In 2004-05 India accounted for over 35 per cent world exports of cashew kernels worth Rs. 2709 crores. Between 1990 and 2004, raw nut production in India increased by 87 per cent. This accounts to 6.2 per cent annual increase. In order to keep pace in the international market, India has to achieve the raw nut

production of atleast 1 million tonnes by 2010 AD and 1.5 Million tonnes by 2015 AD and that too at competitive cost. India should also explore the untapped source for exporting its processed kernels.

World production of raw nuts during 1969-71 was 0.408 million ton. This has increased to 0.4713 million ton during the year 1989-91. Assuming 20 per cent as the output of kernel production, the production of kernel has increased from 0.081 million ton during 1969-71 to 0.094 million ton during the period 1989-91. This amounts to an increase of about 15.5 per cent in the consumption of kernels during 20 years. With the nutritional awareness and the stable price in the international market for cashew kernels, this trend in the consumption of cashew kernels is expected to continue in coming years.

During 1969-71, 78.3 per cent of the world production of raw nuts was contributed by Africa while Asia and Latin American countries contributed 15.0 and 6.7 per cent respectively. In the year 1989-91, Africa's contribution of raw nuts dropped to 24.4 per cent while Asia and Latin American contributions increased to 48.7 and 26.9 per cent respectively. The total production of raw nuts in the world increased from 0.4075 million ton in 1969-71 to 0.4713 million ton in 1989-91. India is the major contributor of raw nuts in Asia. In this scenario, SWOT analysis is furnished below:

6.1 Strength

One of the main advantages which India enjoys is the superior processing capacity established in the country. Further in the international trade, linkages developed by India are much stronger than any other country. India exports cashew to over 65 countries of the world and India has been in this trade for over one century and Indian Cashew is considered as best. Another advantage for the cashew export itself is that none of the cashew importing countries have cashew cultivation. India also has the advantage of importing raw nuts from other cashew producing countries.

There is best linkage between organizations dealing with Research (NRCC, AICRP-Cashew, SAUs) and those engaged in development (DCCD, State Dept. of Hort. / Agr.) and those working on export promotion (CEPC) & Industries.

India also has the advantage of organized Development Directorate established in 1966. Even though, there was little impact of development programmes in the earlier years, of late there is considerable support for programmes by Directorate of Cashewnut and Cocoa Development (DCCD), Kochi. Further in most of the cashew growing states, there is a separate unit which monitors the central sector schemes sanctioned by the Government of India. It must be possible for us to take the advantage of both research as well as development network established in the

country to further booststhe crop prospects in the years to come.

India also has Cashew Export Promotion Council of India (CEPC), Kochi established in 1955. This export promotion council explores the prospective markets and as per the present estimation, we would be in a position to market more than 0.15 million ton of cashew kernels. Further, in the international market Indian cashew kernels are rated as the best and the demand for the same is likely to continue as compared to cashew kernels which are processed mechanically by other countries.

Availability of high yielding varieties released from different Research Centres and Agricultural Universities during last 25 years is one of the major strengths. Out of the 37 varieties released so far 27 varieties have the potential of 1 ton/ha. Some of the high yielding varieties released recently having yield potential of 10 kg/tree/year by tenth to twelfth year at a plant density of 200 plants/ha with a spacing of 10m x 5m hedge row system will help to realize even 2 tonnes/ha. The recently released varieties have bolder kernels and bring premium price on export.

As large planting material is needed both for area expansion and replanting programmes, regional nurseries have been established and these nurseries have the capacity of producing abut 60-70 lakh grafts annually and graft production is being increased every year with establishment of more nurseries. This will help in increasing the production of raw nuts and achieving self sufficiency by 2015 AD.

Processing units established in the country have a processing capacity of 1.0 million ton. With the increased production of raw nuts, large processing capacity established could be better used for enhancing India's kernel production thereby increasing the export earnings.

Recently, large plantations under private sector are being established. Mostly these plantations are being established in Tamil Nadu. They help in increasing production of raw nuts as these plantations have been raised with high yielding varieties. Kerala has declared cashew as plantation crop because of which there is exemption on land ceiling for cashew plantation. It is likely that corporate sector may come to the cashew cultivation in a big way due to this change in the policy of the government on land ceiling.

6.2 Weaknesses

Low productivity of cashew in India is the major weakness. Shortage of rawnuts and higher cost of production are also the important aspects coming in the way of smooth running of cashew industries. Indian needs to import huge quantity of raw cashewnuts from abroad for feeding its factories. Another research weakness is the non-availability of efficient and cost effective technology for the utilization of cashew apple which is otherwise being wasted. India, being a developing country cannot

afford to waste this highly nutritious fruit and if apples are utilized economically and effectively, farmers would get additional income from cashew apples in addition to the income from nuts.

As processing is done in India mainly by women workers and during the shelling of nuts they do get harmful effects of CNSL on their hands, the present awareness in the protection of women from the hazards may be one of the points which needs to be sorted out soon for preventing problems in processing industries. Developing suitable protective measures for these women from the hazards of processing especially the CNSL will be necessary if Women's Rights Commission is taking up the issue.

Transfer of Technology from Research centres to Farmers Fields is not adequate.

At present the package which is used for the export of cashew kernels is quite expensive. We need to develop low cost packaging acceptable to European countries so that Indian produce can compete with kernels being exported from other countries.

Although extensive research work has been done since 1950's, very little work has been done on the understanding of basic metabolic changes during flowering , which is one of the major weaknesses. This needs immediate attention so that, synchronized flowering could be achieved which would help farmers in reducing the harvesting period.

In the frontiers areas of Bio-technology, product diversification, IPM particularly pheromone technology, technical expertise is inadequate.

6.3 Opportunities

As mentioned earlier infrastructure for research and development can be effectively exploited with proper financial input. One of the factors, which is in favour of the cashew cultivation is the stable price of the cashew kernels in the international market compared to other edible nuts like almonds, hazel nuts etc. The prices of cashew kernels are most stable. With the effective market strategy India has a good opportunity to catch sizable market in the international trade and another factor which can be exploited is growing food choice in the European countries. If we are able to develop cashew kernels with higher nutritive value it could be possible for us to exploit the better markets which are available in the European countries.

India’s cashew kernels are ranked as best in quality.

It is also advantageous to have a variety with lesser free sterol and higher triglyceride content as glycerides are rich in unsaturated fatty acids. Cashew kernels compare

well with other tree nuts and scores well with regard to some of the factors such as higher protein, carbohydrate, minerals and unsaturated fatty acid contents and very nutritious. Cashew kernels are energy rich, with higher protein and fat, low levels of saturated fatty acids and soluble sugars and higher levels of poly unsaturated fatty acids which lowers the blood cholesterol level through enhancing the levels of High Density Lipoprotein (HDL) cholesterol and reducing levels of low Density Lipoprotein (LDL) cholesterol. Thus cashew kernel is safe food for people of all ages. The major exports of cashew is in the form of wholes accounting to 70 to 80 per cent of the quantity exported, while the broken kernels, such as splits, baby bits, buts, etc. account for the remaining. While there is stable and premium price for the wholes over the years, export of splits and buts fetch much lower price. Therefore, it is worthwhile to think of value addition for such low grade kernels. Cashew kernels are rich in fat (around 50%) and the possibility of extracting cashew kernel butter and its utilization in cosmetic industry needs to be looked into. Large white pieces (LWP) which fetch low price in the international market are ideal for such a venture. Similarly, low grade bits and pieces if used in confectionary industries and marketed as chocolate, sugar and honey coated pieces, the prices will certainly be much higher. Efforts in this direction have so far been very minimal and research prioritization for value addition and export orientation is essential.

Value addition has great scope in cashew.

Organic cashew can be profitably exported. As cashew is basically organic by default. So easily it can be converted into organic. The research net work available in the country must work on this aspect and exploit the opportunity which is available. Even if there is slight yield reduction when cashew is produced organically, it is more profitable through the higher market value which the organically produced food products fetch in the international market.

Research efforts in developing integrated pest management have given some encouraging leads. There is ample scope for development of eco-friendly pest management approach through the use of pheromone and kairomone technology.

Cashew apple can be utilized for bio-fuel and industrial alcohol production.

The by-product Cashew Nut Shell Liquid (CNSL) has good scope in emerging field of Nano-Technology which has lot of application in Medical field for targetted drug delivery.

6.4 Threats

The South East Asian countries namely, Indonesia. Vietnam and Thailand have taken up cashew cultivation in the recent years. Brazil has also initiated well organized state supported programme of cashew development. Panama has also

entered into the scene. Research efforts of cashew are also started in Brazil by establishing a National Research Centre or Cashew. In addition research efforts are also in progress in Tanzania (Tanzanian Agricultural Research Organization Research Institute (TARO-RI), Naliendele (Mtwara) ; Brazil (EMBRAPA - National Research Centre for Cashew, Fortaleza, Ceara State) ; China (Hainan Cashew High Yield Research Centre, Hainan) ; Vietnam (Cashew Training Research Centre, Binh Duang and Australia (CSIRO Research Centre, Darwin).

As many African countries are establishing their own cashew processing units to process their cashew nuts, India may not be able to continue to import raw cashewnuts from those countries to feed our cashew factories. This threat can be over come if we can develop an aggressive market strategy to import raw nuts from some South East Asian countries which are yet to develop proper processing facilities.

While India has started research in the early 1950s the research institutions in the other countries even though are of recent origin, have already established data base of the literature which is already published from India. Further the support which some of the countries like Vietnam and Myanmar are receiving from international organizations for research on cashew is also of concern to India. While in India we had started this crop cultivation in neglected conditions these South East Asian countries which are now taking up cashew cultivation are utilizing some of the best areas suitable for higher production.

7. PERSPECTIVE

Assured market stability is most essential for the development of any tree crop in the country. Cashew being primarily export oriented crop and the prices in the international market for cashew kernels will be the guiding force. One of the important features is the stability in the prices of cashew in the international market as compared to other tree nuts like almonds, hazel nuts, etc. It is estimated that 60 per cent of cashew kernels in the world is consumed in the form of snacks while the remaining 40 per cent is in the form of confectionary. In the recent years, there has been considerable demand for the edible nuts, especially in the countries which are health-conscious. Among the tree nuts, cashew compares well in its nutritive value and in the new version of the traditional Mediterranean Diet Pyramid developed by the World Health Organization, the tree nuts including cashew, were placed at the base of the pyramid along with fruits, vegetables and legumes, encouraging daily consumption. Cashew kernels contain 50 per cent fat of which 82 per cent is unsaturated fatty acids and free from cholesterol. The carbohydrate content is low and safe for consumption even by the diabetic patients. With the aggressive market campaigning projecting these quality and nutritive features, the international demand can be expected to increase.

From the Indian point of view to maintain and sustain the competitive edge and share in the world market, it is necessary to produce adequate quantity of raw nuts to meet the processing capacity established in the country without depending on import of raw nuts. The South-East Asian countries especially Vietnam which have taken up cashew cultivation in the recent years are also likely to be the competitors in the years to come. As mentioned elsewhere, already 0.855 million ha is under the crop and further expansion of the area is not ruled out and farmers are encouraged to expand area under cashew. The target for raw cashewnut production by 2010 is 0.9 million tons (9 lakh tons), by 2015 is 1.6 million tons (16 lakh tons) and by 2020 is 2.2 million tons (22 lakh tons). However, most of the newer areas which are being brought under cashew cultivation, are highly degraded with a low fertility and may not be conducive for production targets envisaged. The strategy is to take up fresh planting with grafts of improved high yielding varieties in newer areas and also to take up replanting with grafts of improved varieties in the areas which are already planted with cashew which are in senile and unthrifty condition and raised from seedling origin of non-descript types. The advantages of replanting are two-fold: (1) these are the confirmed areas suitable for cashew cultivation and (2) as these are under crop cover for a longer period, the soil degradation is much less. Therefore, it is an opportune time for the research centres to disseminate the technologies developed especially the high yielding varieties with export grade kernels and high nutritive values. It may also be necessary to develop package of practices which is cost-effective so that the cost of production is reduced and processed kernels can be priced competitively in the international market. In order to get premium price for the Indian cashew, efforts should be made to develop technology for producing cashew organically which will appeal to the health-consciousness consumers in the developed countries. Not only for market competitiveness but also to reduce and rationalize the pesticide use it may also be necessary to develop suitable IPM having components of field tolerant varieties and pheromone/kairomone technology.

Cashew apple is a by-product of cashew crop which is not being utilized properly in the country except in Goa where it is used for preparation of alcoholic drink known as “Feni”. Since petrol and diesel are costly and most of it are imported from abroad. The cashew apple can be utilized to prepare ethanol / bio-fuel for mixing with petrol so that import bill on this account can be reduced. Industrial alcohol also can be produced from cashew apple.

Another by-product known as Cashew Nut Shell Liquid (CNSL) finds extensive industrial use like furnace lining, textile industry, preparation of varnish, paints, resins, timber protection etc. Recently CNSL has been found to have great utility in emerging field of Nano-technology which has medical application in targetted drug delivery.

Both Cashew and Mango come under same Botanical family Anacardiaceae. In Konkan region of Maharashtra Cashew as well as Mango are grown by farmers.

Since mango fruit are perishable item and when there is glut in the market, price of mango fruit falls and thereby mango farmers are put into distress. Cashew nut is not a perishable item and can be stored safely for a maximum period of 9 months without deterioration in quality and cashew farmers can sell the nuts when price is good and need not make distress sale. Hence, nowadays mango farmers are turning towards cashew and taking up cashew plantation in large scale. Even in plains region of Karnataka (such as in Kolar district) same trend is being observed wherein farmers are preferring cashew to mango.

In Kerala where rubber and cashew are widely cultivated, the cashew is in a disadvantage position. As the prices of Rubber has shot up recently, farmers prefer rubber over cashew. However, it may be seen that Rubber needs humid tropical climate and suited only to heavy rainfall area while cashew can be cultivated both in tropical humid as well as relatively drier climate. In drier areas rubber is not a competitor for cashew.

High density planting is a best method to increase yield per unit area (productivity). High density planting system, however, needs a suitable dwarf and compact cashew varieties so that overlapping of canopy is kept at minimum. In India suitable dwarf and compact types with high yield are not available. It is reported that Brazil which is the home of cashew has dwarf and compact cashew varieties with high yield. The earlier effort to get these dwarf and compact types to India has failed since Brazil does not want to part with this material. Fresh efforts are needed at Government to Government level through Memorandum of Understanding (MOU) or Work Plan between Indian Govt. and Brazil Govt. to introduce these special cashew types to India. It is also reported that Brazil also has special cashew apple types suitable for fresh consumption without much astringency taste. In the MOU / Work Plan special cashew apple types can also be included for introduction to India.

For translating these perspectives into reality, the following programmes are contemplated:

7.1 Research Programmes

7.1.1 Crop Improvement

1. Collection, conservation, evaluation and cataloguing of both exotic and indigenous germplasm accessions (including from non-traditional areas).

2. Introduction of dwarf and compact cashew types from Brazil, home of cashew and African countries through NBPGR.

3. Development of dwarf and compact cashew varieties suitable for high density planting.

4. Development of plant ideotype concept for cashew

5. Collection of tolerant types to tea mosquito bug/cashew stem and root borer, drought and saline soils etc., and related species and genera from cashew growing regions.

6. Evolving varieties with high yield, resistance to biotic and abiotic stresses with better flowering behaviour / characters (synchronized and staggered) and better nut and kernel quality for internal consumption and export.

7. Establishment of long-term conservation field block of germplasm.

8. Standardization of micropropagation techniques for multiplication of cashew elite lines/root stocks.

9. Molecular characterization of germplasm and varieties through DNA (RAPD / ISSR / SSR) and isozyme markers.

10. Identification of molecular markers linked to economic characters in cashew and construction of genetic maps.

11. Transformation studies for insect resistance and testing and evaluation of transgenics.

7.1.2 Crop Management

1. Studies on compatibility of rootstocks and scions and stionic effect

2. Screening of rootstocks for dwarfing and biotic and abiotic stresses.

3. Integrated Plant Nutrient Management (IPNM) including nutrient budgeting, orchard management, weed management, irrigation management, micronutrient deficiencies management and soil and water conservation techniques for achieving targeted yield.

4. Physiology of flowering and off-season flowering including studies on hormones.

5. Canopy management, rejuvenation of old cashew plantations /orchards

6. Canopy architecturing and management to suit the requirement of different plant densities and system of planting.

7. Manipulation of canopy size through chemical interventions

8. Detailed studies on high density planting system to increase productivity of cashew.

9. Development of cashew based cropping system (mixed and intercropping).

10. Studies on soil / substrate improvement, enhancement and basin management.

11. Organic farming research including certification.

12. Integrated cashew based farming system research.

13. Studies on role of pollinators in cashew for enhancing yield.

7.1.3 Crop Protection

1. Studies on kairomones and pheromones for effective and economic control of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB) – Network project.

2. Development of eco-friendly IPM strategies including Entomo Pathogenic Nematodes (EPN) for control of major insect pests.

3. Standardization of mass rearing of CSRB, flower and fruit pests and their natural enemies.

4. Standardization of Semi-synthetic diet (SSD) for rearing of CSRB.

5. Etiology and transmission studies on yellow leaf spot disease.

6. Investigations on panicle drying (in absence of TMB).

7. Analysis of pesticide residues in cashew produce and cashew ecosystem to address concerns of food quality standards.

7.1.4 Post Harvest Technology

1. Studies on designing various cashew processing machineries and their evaluation.

2. Development of low cost, on-farm machinery for cashew processing such as mini cashew processing unit, moisture meter for raw nut etc

3. Development of value added products.

4. Developing technologies for alternative use of byproducts of cashew processing industry such as cashew kernel rejects, Cashew Nut Shell Liquid (CNSL), cashew shell cake, cashew kernel testa etc., and cashew apple pomace.

5. Exploring the possibility of extraction of nutraceuticals from cashew apple pomace such as natural colours, flavours, pectin and nutritionally beneficial compounds.

6. Assessment of bioavailability of nutritionally important minerals in cashew apple powder / pomace / cashew kernel.

7. Exploring the possibility of production of industrial alcohol / bio-fuel from cashew apple.

8. Establishment of closer ties with processors for addressing industry related problems.

9. Development of cream to address the problem of Cashew Nut Shell Liquid (CNSL) being affecting hands of labourers engaged in shelling operation.

7.1.5 Transfer of Technology

1. Farmers participatory technology development programme.

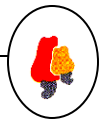
2. Impact of cashew production technology on increase in area and productivity of cashew.

3. Analysis of socio-economic impact of cashew cultivation.

4. Production and supply of quality planting material of improved cashew varieties.

5. Massive replanting programme to replace senile unthrifty cashew plantations of seedling origin.

6. Developing training methodologies for transfer of technology in cashew.



7 Utilizing and standardizing mass media based Transferof Technology (TOT).

8. Case studies on profitable cashew based cropping systems for popularization.

9. Organizing demonstration plots, village adoption, and trainers training programmes.

10. Estimation of cost of cultivation.

7.1.6 Computer Application

1. Web page updating and establishing linkage with other Govt., Organization (Agriculture and Horticulture and Marketing Departments).

2. Updating and creating data base on cashew

3. Development of CD package on production and protection technologies and sustainability of cashew cultivation and success stories.

7.2 Human Resource Development

Human Resource Development Plan (Training of scientists in frontier areas of technology during IX Plan with following details)

Sl. No.	Frontier area of training	Institute where training will be given	Tentative budget estimate (Rs. in lakhs)
1.	Molecular markers / Molecular breeding	University of California, Davis, USA, CA 95616 Purdue University, West Lafayette, Indiana, USA	15.00
2.	Nutrients management studies in cashew and alternate technologies for cashew apple utilization.	Embrapa, Brazilian Agricultural Research Corporation, Ministry of Agriculture and Food Supply, Sain Parque Rural, W3N, 70770-901, Basillia DF Brazil. Nurient Management Institute, NMIBV, Agro Business park 20, 6708 PW, Wageningen, Netherland	20.00
3	Pheromones/kairomones	Insect attractants, behaviour and basic biology Research Laboratory, USDA, ARS, Gainesville, FL 32604, USA University of Tokyo, Yayoi-1-1-1, Bunkyo-ku, Tokyo-113, Japan Laboratory of Insect Behaviour, National Institute of Agrobiological Sciences, Tsukuba, Ibaraki, 305-8634, Japan	15.00
4.	Developing alternate technologies for cashew apple utilization.	National Resource Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, United Kingdom	20.00
	Total		70.00

8. ISSUES AND STRATEGIES

Issues which should receive immediate attention are the germplasm conservation, developing varieties, molecular characterization of germplasm accessions and mass multiplication of planting material required for replanting / fresh planting envisaged in the years to come. Integrated nutritive management including organic farming is another issue which should receive the prioritization in research programmes.

Canopy architecturing and limb pruning techniques should be standardized to suit the requirement of different plant densities and system of planting.

Organic farming is the need of the hour and in cashew, feasibility of bio-dynamic farming, Rishi Krishi and homa farming need to be looked into.

Basic research regarding nutrient uptake, its utilization, nutrient dynamics and partitioning need to be studied in high density planting which has been shown to be highly beneficial in terms of accommodating more number of plants/ha without affecting the yield upto 12th year and realizing higher yield.

Usage of pesticides should be minimized in cashew and suitable IPM package should be developed involving pheromone and kairomone technology.

Except in Goa, cashew apple is wasted in almost all the states. Even though a number of products have been developed both by the Universities and CSIR laboratories market acceptability is very low. Developing acceptable product from the apple will increase farmers attractiveness for taking up cashew cultivation profitably. There is great scope to utilize cashew apple for production of bio-fuel and industrial alcohol.

9. PROGRAMMES

9.1 Programmes with time-frame

	Programme	Time Scale		
		2007-12	2012-17	2017-2025
9.1.1	**Crop Improvement**			
1.	Collection, conservation, evaluation and cataloguing of both exotic and indigenous germplasm accessions (including from non-traditional areas).	✓	✓	✓
2.	Introduction of dwarf and compact cashew types from Brazil, home of cashew and African countries through NBPGR.	✓		
3.	Development of dwarf and compact cashew varieties suitable for high density planting.	✓		
4.	Development of plant ideotype concept for cashew	✓		
5.	Collection of tolerant types to tea mosquito bug/cashew stem and root borer, drought and saline soils etc., and related species and genera from cashew growing regions.	✓	✓	✓
6.	Evolving varieties with high yield, resistance to biotic and abiotic stresses with better flowering behaviour / characters (synchronized and staggered) and better nut and kernel quality for internal consumption and export.	✓	✓	✓
7.	Establishment of long-term conservation field block of germplasm.	✓	✓	✓
8.	Standardization of micropropagation techniques for multiplication of cashew elite lines/root stocks.	✓		
9.	Molecular characterization of germplasm through DNA (RAPD / ISSR / SSR) and isozyme markers.	✓		
10.	Identification of molecular markers linked to economic characters in cashew and construction of genetic maps.	✓	✓	
11.	Transformation studies for insect resistance and testing and evaluation of transgenics.		✓	✓
9.1.2	**Crop Management**			
1.	Studies on compatibility of rootstocks and scions and stionic effect	✓		
2.	Screening of rootstocks for dwarfing and biotic and abiotic stresses.	✓	✓	✓

	Programme	Time Scale		
		2007-12	2012-17	2017-2025
3.	Integrated Plant Nutrient Management (IPNM) including nutrient budgeting, orchard management, weed management, irrigation management, micronutrient deficiencies management and soil and water conservation techniques for achieving targeted yield.	✓	✓	✓
4.	Physiology of flowering and off-season flowering including studies on hormones.	✓		
5.	Canopy management, rejuvenation of old cashew plantations /orchards	✓		
6.	Canopy architecturing and management to suit the requirement of different plant densities and system of planting.	✓	✓	
7.	Manipulation of canopy size through chemical interventions	✓	✓	
8.	Detailed studies on high density planting system to increase productivity of cashew.	✓		
9.	Development of cashew based cropping system (mixed and intercropping).	✓		
10.	Studies on soil / substrate improvement, enhancement and basin management.	✓	✓	
11.	Organic farming research including certification.	✓		
12.	Integrated cashew based farming system research.	✓	✓	
13.	Studies on role of pollinators in cashew for enhancing yield.	✓		
9.1.3	**Crop Protection**			
1.	Studies on kairomones and pheromones for effective and economic control of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB) – Network project.	✓		
2.	Development of eco-friendly IPM strategies including Entomo Pathogenic Nematodes (EPN) for control of major insect pests.	✓	✓	✓
3.	Standardization of mass rearing of CSRB, flower and fruit pests and their natural enemies.	✓		
4.	Standardization of Semi-synthetic diet (SSD) for CSRB.	✓		
5.	Etiology and transmission studies on yellow leaf spot disease.	✓		
6.	Investigations on panicle drying (in absence of TMB).	✓		

	Programme	Time Scale		
		2007-12	2012-17	2017-2025
7.	Analysis of pesticide residues in cashew produce and cashew ecosystem to address concerns of food quality standards.	✓		
9.1.4	**Post Harvest Technology**			
1.	Studies on designing various cashew processing machineries and their evaluation.	✓	✓	✓
2.	Development of low cost, on-farm machinery for cashew processing such as mini cashew processing unit, moisture meter for raw nut etc	✓		
3.	Development of value added products.	✓	✓	
4.	Developing technologies for alternative use of byproducts of cashew processing industry such as cashew kernel rejects, Cashew Nut Shell Liquid (CNSL), cashew shell cake, cashew kernel testa etc., and cashew apple pomace.	✓	✓	
5.	Exploring the possibility of extraction of nutraceuticals from cashew apple pomace such as natural colours, flavours, pectin and nutritionally beneficial compounds.	✓		
6.	Assessment of bioavailability of nutritionally important minerals in cashew apple powder / pomace / cashew kernel.	✓		
7.	Exploring the possibility of production of industrial alcohol / bio-fuel from cashew apple.	✓	✓	
8.	Establishment of closer ties with processors for addressing industry related problems.	✓	✓	✓
9.	Development of cream to address the problem of Cashew Nut Shell Liquid (CNSL) being affecting hands of labourers engaged in shelling operation.	✓	✓	
9.1.5	**Transfer of Technology**			
1.	Farmers participatory technology development programme.	✓		
2.	Impact of cashew production technology on increase in area and productivity of cashew	✓		
3.	Analysis of socio-economic impact of cashew cultivation.	✓		
4.	Production and supply of quality planting material of improved cashew varieties.	✓	✓	✓
5.	Massive replanting programme to replace senile unthrifty cashew plantations of seedling origin.	✓	✓	

	Programme	Time Scale		
		2007-12	2012-17	2017-2025
6.	Developing training methodologies for transfer of technology in cashew.	✓		
7.	Utilizing and standardizing mass media based Transfer of Technology (TOT).	✓	✓	✓
8.	Case studies on profitable cashew based cropping systems for popularization.	✓	✓	
9.	Organizing demonstration plots, village adoption, and trainers training programmes.	✓	✓	✓
10.	Estimation of cost of cultivation.	✓	✓	✓
9.1.6	**Computer Application**			
1.	Web page updating and establishing linkage with other Govt., Organization (Agriculture and Horticulture and Marketing Departments).	✓	✓	✓
2.	Updating and creating data base on cashew	✓	✓	✓
3.	Development of CD package on production and protection technologies and sustainability of cashew cultivation and success stories.	✓	✓	✓

9.2 XI Plan Programmes

	Programme	Time Scale 2007-12
9.1.1	**Crop Improvement**	
1.	Collection, conservation, evaluation and cataloguing of both exotic and indigenous germplasm accessions (including from non-traditional areas).	✓
2.	Introduction of dwarf and compact cashew types from Brazil, home of cashew and African countries through NBPGR.	✓
3.	Development of dwarf and compact cashew varieties suitable for high density planting.	✓
4.	Development of plant ideotype concept for cashew	✓
5.	Collection of tolerant types to tea mosquito bug/cashew stem and root borer, drought and saline soils etc., and related species and genera from cashew growing regions.	✓
6.	Evolving varieties with high yield, resistance to biotic and abiotic stresses with better flowering behaviour / characters (synchronized and staggered) and better nut and kernel quality for internal consumption and export.	✓
7.	Establishment of long-term conservation field block of germplasm.	✓
8.	Standardization of micropropagation techniques for multiplication of cashew elite lines/root stocks.	✓

	Programme	Time Scale 2007-12
9.	Molecular characterization of germplasm through DNA (RAPD / ISSR / SSR) and isozyme markers.	✓
10.	Identification of molecular markers linked to economic characters in cashew and construction of genetic maps.	✓
9.1.2	**Crop Management**	
1.	Studies on compatibility of rootstocks and scions and stionic effect	✓
2.	Screening of rootstocks for dwarfing and biotic and abiotic stresses.	✓
3.	Integrated Plant Nutrient Management (IPNM) including nutrient budgeting, orchard management, weed management, irrigation management, micronutrient deficiencies management and soil and water conservation techniques for achieving targeted yield.	✓
4.	Physiology of flowering and off-season flowering including studies on hormones.	✓
5.	Canopy management, rejuvenation of old cashew plantations /orchards	✓
6.	Canopy architecturing and management to suit the requirement of different plant densities and system of planting.	✓
7.	Manipulation of canopy size through chemical interventions	✓
8.	Detailed studies on high density planting system to increase productivity of cashew.	✓
9.	Development of cashew based cropping system (mixed and intercropping).	✓
10.	Studies on soil / substrate improvement, enhancement and basin management.	✓
11.	Organic farming research including certification.	✓
12.	Integrated cashew based farming system research.	✓
13.	Studies on role of pollinators in cashew for enhancing yield.	✓
9.1.3	**Crop Protection**	
1.	Studies on kairomones and pheromones for effective and economic control of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB) – Network project.	✓
2.	Development of eco-friendly IPM strategies including Entomo Pathogenic Nematodes (EPN) for control of major insect pests.	✓
3.	Standardization of mass rearing of CSRB, flower and fruit pests and their natural enemies.	✓
4.	Standardization of Semi-synthetic diet (SSD) for CSRB.	✓
5.	Etiology and transmission studies on yellow leaf spot disease.	✓
6.	Investigations on panicle drying (in absence of TMB).	✓
7.	Analysis of pesticide residues in cashew produce and cashew ecosystem to address concerns of food quality standards.	✓

	Programme	Time Scale 2007-12
9.1.4	**Post Harvest Technology**	
1.	Studies on designing various cashew processing machineries and their evaluation.	✓
2.	Development of low cost, on-farm machinery for cashew processing such as mini cashew processing unit, moisture meter for raw nut etc	✓
3.	Development of value added products.	✓
4.	Developing technologies for alternative use of byproducts of cashew processing industry such as cashew kernel rejects, Cashew Nut Shell Liquid (CNSL), cashew shell cake, cashew kernel testa etc., and cashew apple pomace.	✓
5.	Exploring the possibility of extraction of nutraceuticals from cashew apple pomace such as natural colours, flavours, pectin and nutritionally beneficial compounds.	✓
6.	Assessment of bioavailability of nutritionally important minerals in cashew apple powder / pomace / cashew kernel.	✓
7.	Exploring the possibility of production of industrial alcohol / bio-fuel from cashew apple.	✓
8.	Establishment of closer ties with processors for addressing industry related problems.	✓
9.	Development of cream to address the problem of Cashew Nut Shell Liquid (CNSL) being affecting hands of labourers engaged in shelling operation.	✓
9.1.5	**Transfer of Technology**	
1.	Farmers participatory technology development programme.	✓
2.	Impact of cashew production technology on increase in area and productivity of cashew	✓
3.	Analysis of socio-economic impact of cashew cultivation.	✓
4.	Production and supply of quality planting material of improved cashew varieties.	✓
5.	Massive replanting programme to replace senile unthrifty cashew plantations of seedling origin.	✓
6.	Developing training methodologies for transfer of technology in cashew.	✓
7.	Utilizing and standardizing mass media based Transfer of Technology (TOT).	✓
8.	Case studies on profitable cashew based cropping systems for popularization.	✓
9.	Organizing demonstration plots, village adoption, and trainers training programmes.	✓
10.	Estimation of cost of cultivation.	✓

	Programme	Time Scale 2007-12
9.1.6	**Computer Application**	
1.	Web page updating and establishing linkage with other Govt., Organization (Agriculture and Horticulture and Marketing Departments).	✓
2.	Updating and creating data base on cashew	✓
3.	Development of CD package on production and protection technologies and sustainability of cashew cultivation and success stories.	✓

9.3 Funds

Collection of germplasm from outside India needs funding from external agencies. IPGRI will be approached for financial support.

In post harvest technology, possibility of industries extending financial support will be looked into and programmes in developing the machinery and alternate technology for cashew apple utilization will be funded from external scheme.

Generation of planting material will be operated by revolving fund scheme which is self financing.

For Basic studies on various aspects including Biotechnology and Biochemistry, funding agencies like DBT and others will be approached or they can be taken up as Adhoc schemes financed by ICAR itself.

10. LINKAGE (COORDINATION AND EXECUTION ARRANGEMENTS)

10.1 International

There are new research institutes on cashew which have been established with funding by International agencies in the countries like Vietnam, Myanmar, etc. A National Research Centre for Cashew in Brazil is also established. Linkages with these institutions will help in exchange of germplasm as well as study tours of scientists for better understanding of field problems. Linkages/collaborations will also be needed with the research centers and IPGRI for germplasm collection in Latin America and African countries.

10.2 National

Linkages between National Research Centre for Cashew, State Agricultural Universities, CSIR laboratories and BARC, Mumbai will be required for taking up basic research in Biotechnology, pheromone studies as well as in developing integrated pest management programme. This collaboration will be necessary for better utilization of resources, which are available with different agencies instead of seeking for additional funding.

Linkages will also be required with the processing industries for taking up some of the research programmes identified in post-harvest technology especially on cashew nut processing and value based products.

10.3 Executing arrangements

The National Research Centre for Cashew is the nodal agency which will be undertaking the programme indicated. The executing arrangements are vested with the Department of Agricultural Research and Education, Ministry of Agriculture, Government of India.
The collaboration between NRCC and International organizations should be executed through Council with support of the International collaborative programme/bilateral agreements.

10.4 Coordination arrangements

The National Research Centre far Cashew is also the headquarters for All India Coordinated Research Project on Cashew. Currently the Director of NRCC is entrusted with the responsibility of coordinating research programmes under the AICRP on Cashew. This research net work coordination will be monitored by ADG (PC) /DDG (Hort.), ICAR.

Coordination between national programmes with international agency will be coordinated at the Council's level directly under the guidance of DDG (Hort.), ICAR.

10.5 Partnership / Linkages / Collaborative Programmes during X / XI Plan (Identifying own requirements in emerging technologies for deriving maximum benefit in critical areas)

A. Within the country

Major Area	Name of Collaborative / Integrated Programme	Whether MOU exists with collaborative agency or not	Collaborative agency	ICAR Share	Financial Involvement Share of Collaborative agency
(a) With other Ministries / Departments at Central State levels					
Graft Production	DCCD, Kochi	No	-	-	-
(b) With Sister Organizations (CSIR / ICMR)					
Value added products	CFTRI, Mysore	No	-	-	To be worked out
Cashew apple utilization	CFTRI, Mysore	No	-	-	To be worked out
Pheromone / kairomone technology	BARC, Mumbai and IICT, Hyderabad	No	-	-	To be worked out
(c) With State Agricultural Universities / Traditional Universities					
DNA Finger printing / Studies on Molecular markers	UAS, Bangalore	No	-	-	To be worked out
(d) With Non-Governmental Organizations (NGOs)					
Establishment of demonstration plots / conducting campaigns	SKDRDP, Dharmasthala	No	-	-	
(e) With ICAR System itself (collaboration amount Institutes / NRCs / PDs / AICRPSs)					
Designing processing machinery	CIAE, Bhopal	No	-	-	To be worked out
Finger printing technique	CPCRI, Kasaragod and NRC for DNA Finger Printing, New Delhi	No	-	-	To be worked out
Kairomones and pheromones	PDBC, Bangalore and CPCRI, Kasaragod	No	-	-	To be worked out

11. CRITICAL INPUTS

Necessary infrastructure for carrying out the research programmes contemplated has already been established at National Research Centre for Cashew. These facilities will also be available for the scientists working in the State Agricultural Universities. However, further strengthening of facilities in areas of biocontrol, pheromone studies and hormone studies are contemplated during the X Plan.

One of the pre-requisites will be to obtain the concurrence from the other institutes/organizations for initiating and pursuing the collaborative programme. It will be necessary that scientific personnel from the collaborating agencies to work in different places for specified period for better utilization of resources. Free movement of scientists between organizations will be a basic need for successful implementation of the programme.

Human resources development in the frontier areas of biotechnology. Molecular markers, molecular breeding, nutrient management, pheromone and kairomone technology has been contemplated. A few scientific posts in the disciplines of Plant Pathology, Agril. Microbiology and Agril. Statistics are required. The imbalances presently existing in the ratios of Scientists and Technical personnel need to be rectified during the XI Plan. Revenue generation can be increased through production of planting material (cashew grafts), undertaking consultancy, imparting training through cashew production technology training courses etc.

11.1 Funds

The main funding source for ongoing programmes will be ICAR as institute budget allocation. However as indicated earlier, outside funding agencies will be approached for conducting research in priority area. In view of the escalating cost of research project, additional funds will be generated by resource generation through technical consultancy, project preparation, selling of planting material and charging for training programmes.

11.2 Manpower

1. The sanctioned posts in IX Plan have been reiterated in X Plan. Proposal has been sent to ICAR for creation of posts.

2. In order to effectively implement the research projects, more number of technical personnel are needed.

12. RISK ANALYSIS

As mentioned earlier, cashew cultivation is being taken up with greater emphasis in the South-East Asian countries where research institutes are also established, with external funding. The linkages suggested above could sometimes be disadvantageous as the information to be gained by other countries could be much more than the benefit which can come for India. A careful programme on the preparation and identification of areas of collaboration will be necessary to safeguard the interest of our country. This is especially in the fields of germplasm and breeding material exchange.

13. REVIEW (REPORTING AND EVALUATION ARRANGEMENTS)

The present arrangement of quarterly reporting of the programme and mid-term review by different committees constituted by the Director of the Centre and review of the projects and drawing up of the technical programmes in the Staff Research Council meeting and Research Advisory Committee meeting is satisfactory. In addition, during the Plan period there should be a mid-term review by the Peer Committee for taking up corrective measures, if any. Timely quinquennial review programme will help in bridging up the gaps in the implementation of the technical programmes.

14. RESOURCE GENERATION

It is proposed to generate resources to a tune of Rs. 100 lakhs through the following means.

1. Generation of planting material for distribution is being funded by operating Revolving Fund Scheme wherein initial capital from seed project financed by ICAR. After 2 to 3 years of operation, the initial capital investment will be returned by the institute from the profit.

2. Institute entertains number of technical enquiries both from farmers as well as large plantations. It is proposed to charge for such consultancy to raise funds for the institute.

3. It is also proposed to generate resources through charging for the preparation of feasibility reports for the establishment of processing units.

4. It is also envisaged to generate resources through product development and refinement and patenting the product / machinery

development resulting in royalty.

5. Collection of fees for soil and leaf analysis.

6. Pesticide residue analysis and soil testing.

7. Testing of newer insecticides / pesticides against major pests of cashew.

Revenue Generation

(Rs. In lakhs)

IX Plan (Actuals)	75.88
X Plan (Actuals)	138.21
XI Plan (Anticipated)	Target yet to be fixed by ICAR

15. OUTPUTS

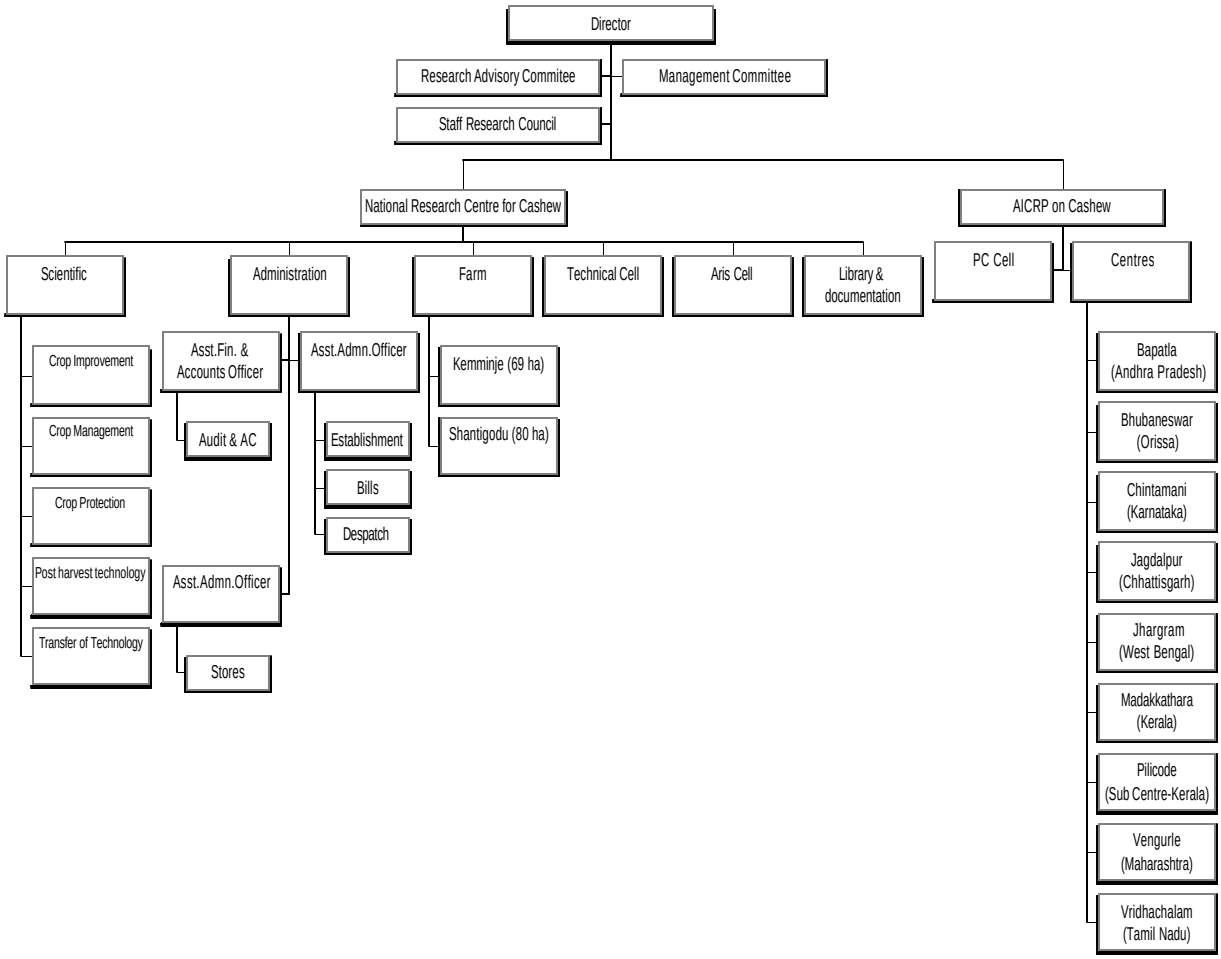
At the end of the programme contemplated it is expected that the varieties and technologies will be available for making India self sufficient in raw nut production. The industry has installed capacity to process upto 1 million ton of raw nuts. Therefore, the current production of 0.539 million ton need to be enhanced to 0.9 million tons (9 lakh tons) by 2010, to 1.6 million tons (16 lakh tons) by 2015 and to 2.2 million tons (22 lakh tons) by 2020 in order to safeguard the interest of the cashew industries as well as of that of the country as import of raw nuts may not be forthcoming by that time. However, as indicated, the programmes contemplated if implemented will be able to meet these challenges and make India self-sufficient in raw cashewnut production.

16. OUTCOME

The technologies developed through implementation of research programmes contemplated helps in enhancing the productivity of cashew resulting in increased production and lesser dependence on import of rawnuts with self reliance on indigenous raw nuts for processing. This would help cashew farmers in terms of realization of higher returns through the technologies developed and adopted. Further, large area is likely to be brought under cashew cultivation even in non-traditional areas. Increasing productivity and expansion of area under cashew will have strong impact on cashew development, in general, and increased production of raw cashewnut in the country, in particular, thereby India becoming self sufficient in raw cashewnut production and continue to maintain premier position in the international cashew trade inspite of stiff competition from other cashew growing countries.

ANNEXURE-I

ORGANISATIONAL SETUP OF NRC-CASHEW



ANNEXURE-II

CASHEW RESEARCH CENTRES

1 – Bapatla (ANGRAU)	8 – Jagdalpur (IGKV)
2 – Bhubaneswar (OUAT)	9 – CRS Anakkayam (KAU)
3 – Chintamani (UAS)	10 – NARP Spl. Station Kottarakkara (KAU)
4 – Jhargram (BCKV)	11 – RARS Pilliicode (KAU)
5 – Madakkathara (KAU)	12 – ARS Ullal (UAS)
6 – Vengurle (BSKKV)	13 – CRS Kavali (ANGRAU)
7 – Vridhachalam (TNAU)	● – NRC Cashew, Puttur

ANNEXURE-III

CASHEW IN INDIA

Year	Area (million ha.)	Production (1000 xt)	Productivity* (kg/ha.)	Import of raw nuts (x 1000 t)	Export of cashew kernels (x 1000 t)	Export earnings (Million Rs.)
1955-56	0.110	79.0	720	63	31	12.9
1956-57	0.110	80.0	730	51	31	14.5
1957-58	0.121	93.0	770	99	36	15.1
1958-59	0.130	99.0	760	125	41	15.8
1959-60	0.140	107.0	760	95	39	16.1
1960-61	0.176	111.0	630	118	44	18.9
1961-62	0.185	113.0	610	102	42	18.1
1962-63	0.212	120.0	570	155	49	19.3
1963-64	0.224	133.0	590	157	51	21.4
1964-65	0.232	141.0	610	191	56	29.0
1965-66	0.241	103.0	427	161	51	27.4
1966-67	0.249	114.0	458	141	51	42.8
1967-68	0.257	119.0	463	168	51	43.0
1968-69	0.266	120.0	451	196	63	60.9
1969-70	0.281	123.0	438	163	60	57.4
1970-71	0.303	127.0	419	169	50	52.0
1971-72	0.320	130.0	406	169	60	61.3
1972-73	0.328	130.0	396	197	66	68.8
1973-74	0.351	135.0	385	150	52	74.4
1974-75	0.361	144.0	399	160	65	108.1
1975-76	0.375	162.0	432	137	54	96.1
1976-77	0.376	162.0	431	74	52	105.9
1977-78	0.386	165.0	427	60	40	147.6
1978-79	0.420	172.0	410	20	27	80.0
1979-80	0.447	180.0	403	24	38	118.0
1980-81	0.464	185.0	400	16	32	140.0
1981-82	0.481	196.0	410	16	31	181.0
1982-83	0.492	201.0	409	1	31	135.0
1983-84	0.502	211.0	420	27	37	151.0
1984-85	0.510	221.0	433	33	32	180.0
1985-86	0.518	234.0	452	23	35	215.0
1986-87	0.523	246.0	470	40	42	334.0
1987-88	0.527	260.0	490	550	35	112.9
1988-89	0.529	274.0	518	30	34	2739.3
1989-90	0.531	286.0	540	59	45	3650.7
1990-91	0.532	295.0	550	833	49	4422.4
1991-92	0.534	305.0	570	106	48	6690.9
1992-93	0.560	349.0	623	135	56	7454.9
1993-94	0.565	348.0	616	190	69	10451.4
1994-95	0.577	322.0	558	231	77	12449.6

Year	Area (million ha.)	Production (1000 xt)	Productivity* (kg/ha.)	Import of raw nuts (x 1000 t)	Export of cashew kernels (x 1000 t)	Export earnings (Million Rs.)
1995-96	0.635	418.0	660	222	68.0	12829.5
1996-97	0.659	430.0	652	192	68.7	12855.0
1997-98	0.701	360.0	513	225	76.6	13961.0
1998-99	0.706	460.0	652	181	75.0	16100.0
1999-00	0.686	520.0	758	201	92.5	24514.0
2000-01	0.720	450.0	625	249	81.7	18785.0
2001-02	0.770	470.0	610	355	97.6	17768.0
2002-03	0.770	506.0	657	401	127.2	20064.0
2003-04	0.780	535.0	686	452	100.8	18546.0
2004-05	0.820	539.0	657	578	127.0	27092.0
2005-06	0.855	573.0	670**	565	114.1	2514.9

*** Productivity on total area basis**

** Productivity is 815 kg/ha on productive area basis

Source : CEPCI, Kochi, Kerala; DCCD, Kochi