



Vision 2050



काजू अनुसंधान निदेशालय

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(Indian Council of Agricultural Research)

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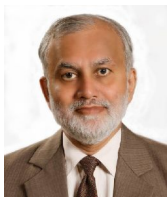
MESSAGE

The scientific and technological inputs have been major drivers of growth and development in agriculture and allied sectors that have enabled us to achieve self reliant food security with a reasonable degree of resilience even in times of natural calamities, in recent years. In the present times, agricultural development is faced with several challenges relating to state of natural resources, climate change, fragmentation and diversion of agricultural land to non-agricultural uses, factor productivity, global trade and IPR regime. Some of these developments are taking place at much faster pace than ever before. In order to address these changes impacting agriculture and to remain globally competent, it is essential that our R&D institutions are able to foresee the challenges and formulate prioritized research programmes so that our agriculture is not constrained for want of technological interventions.

It is a pleasure to see that Directorate of Cashew Research (DCR), Puttur, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision-2050 document. The document embodies a pragmatic assessment of the agricultural production and food demand scenario by the year 2050. Taking due cognizance of the rapidly evolving national and international agriculture, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish DCR all success in realisation of the Vision-2050.

(SHARAD PAWAR)



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FOREWORD

The Indian Council of Agricultural Research, since inception in the year 1929, is spearheading science and technology led development in agriculture in the country. This is being accomplished through agricultural research, higher education and frontline extension undertaken by a network of research institutes, agricultural universities and Krishi Vigyan Kendras. Besides developing and disseminating new technologies, ICAR has also been developing competent human resources to address the present and future requirements of agriculture in the country. Committed and dedicated efforts of ICAR have led to appreciable enhancement in productivity and production of different crops and commodities, which has enabled the country to raise food production at a faster rate than the growth in demand. This has enabled the country to become self-sufficient in food and emerge as a net food exporter. However, agriculture is now facing several challenges that are expected to become even more diverse and stiffer. Natural resources (both physical and biological) are

deteriorating and getting depleted; risks associated with climate change are rising, new forms of biotic and abiotic stress are emerging, production is becoming more energy intensive, and biosafety concerns are growing. Intellectual property rights and trade regulations impacting technology acquisition and transfer, declining preference for farm work, shrinking farm size and changes in dietary preferences are formidable challenges.

These challenges call for a paradigm shift in our research approach to harness the potential of modern science, innovations in technology generation and delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive.

It is an opportune time that the formulation of 'Vision-2050' by ICAR institutions coincides with the launch of the national 12th Five Year Plan. In this Plan period, the ICAR has proposed to take several new

initiatives in research, education and frontline extension. These include creation of consortia research platforms in key areas, wherein besides the ICAR institutions, other science and development organizations would be participating; short term and focused research project through scheme of extramural grants; Agri-Innovation fund; Agri-incubation fund and Agri-tech Foresight Centres (ATFC) for research and technology generation. The innovative programme of the Council, 'Farmer FIRST' (Farmer's farm, Innovations, Resources, Science and Technology) will focus on enriching knowledge and integrating technologies in the farmer's conditions through enhanced farmer-scientist interface. The 'Student READY' (Rural Entrepreneurship and Awareness Development Yojana) and 'ARYA' (Attracting and Retaining Youth in Agriculture) are aimed to make agricultural education comprehensive for enhanced entrepreneurial skills of the agricultural graduates.

I am happy to note that the Vision-2050 document of **Directorate of Cashew Research, Puttur** has been prepared, based on the assessment of present situation, trends in various factors and changes in operating environment around agriculture to visualize the agricultural scenario about 40 years hence and chalk out a demand-driven research

agenda for science-led development of agriculture for food, nutrition, livelihood and environmental security, with a human touch.

I am sure that the 'Vision-2050' would be valuable in guiding our efforts in agricultural R&D to provide food and nutritional security to the billion plus population of the country for all times to come.

(S. Ayyappan)

Dated the 27th June, 2013

New Delhi

PREFACE

Cashew is a very important horticultural crop of India which was introduced by Portuguese travellers in 16th century mainly for the purpose of soil and water conservation. In the early part of 20th century itself, India was the first country in the world to take advantage of the export potential of cashew kernels. According to FAO (2010), Nigeria, India, Ivory Coast, Vietnam and Indonesia are leading cashew producing countries in the world. In India, it is grown in an area of 9.91 lakh ha with production of 6.92 lakh tonnes of raw nuts per annum. It is grown mainly in Maharashtra, Goa, Karnataka and Kerala along the west coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal along the east coast. It is also grown to a limited extent in non-traditional areas such as Bastar region of Chattisgarh and Kolar (Plains) region of Karnataka, Gujarat, and Jharkhand and in North Eastern Hilly region.

Cashew kernels are highly nutritious containing protein (21.0%), fat (47.0%), carbohydrates (22.0%), minerals and vitamins. It is considered as a safe food as bulk of fatty acids in the kernel fall under unsaturated fatty acid group. Cashewnut Shell Liquid (CNSL), a by-product finds use in a number of chemical industries. Cashew apple is rich in anthocyanin and ascorbic acid and has potential for utilization in various delicious preparations as well as production of industrial alcohol which needs further exploitation. Considerable progress has been made in cashew research since 1950. The first systematic effort to visualize the challenges and opportunities, and formulate strategy for research was undertaken in the year 1997 by preparing Vision 2020 – NRC Cashew Perspective Plan. The next attempt was made for preparing Vision 2025: NRC Cashew Perspective Plan to address the changes that had taken place. In 2011, Vision 2030-DCR was prepared highlighting the strategies to meet

the challenges and tap the opportunities by harnessing the power of science. The present document Vision 2050-DCR has been prepared in view of growing demand for cashew and to meet the urgent necessity of attaining self sufficiency in production. In this document, the challenges are examined and new opportunities / strategies are discussed to march towards the set goal.

I take this opportunity to place on record our sincere gratitude to Dr. S.Ayyappan, Secretary, DARE and Director General, ICAR for the constant guidance and encouragement. We are also greatly indebted to Dr. N.K. Krishna Kumar, Deputy Director General (Hort.) and Dr. S.K. Malhotra, ADG (Hort.) for thier guidance and support.

I am thankful to the scientists of this Directorate who have compiled the information and presented in this document. I am confident, if all the strategies documented are implemented successfully, India would be able to attain self-sufficiency in raw nut production soon and maintain its supremacy in global trade of cashew.

June 2013
Puttur

(P.L. Saroj)
Director

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1. CONTEXT

Cashew is one of the major export oriented horticultural crops of India. In the early part of 20th century itself, India was the first country to develop technology for extraction of cashew kernels from raw cashewnuts and exploit the export potential of these kernels. Indian cashew kernel is ranked best in quality in the International market. India exports 1.312 lakh tonnes of cashew kernels per annum to over 65 countries and is a prominent trader for over a century. The major countries that import Indian cashew are United States of America (USA), Netherlands, United Kingdom, United Arab Emirates, Japan, France, Saudi Arabia, Spain, Russia, Germany, Canada and Greece. Owing to its high nutritional value and increasing affordability by the consumers, demand for cashew continues to increase globally as well as domestically.

India is producing about 7.0 lakh tonnes of raw cashewnuts annually. The cashew processing units in the country need about 13-14 lakh tonnes of raw cashewnuts annually. In order to meet the requirement of the processing industry, every year, India imports about 6.0 – 7.0 lakh tonnes of raw cashewnuts from African and South East Asian countries. As many of these cashew producing African countries started strengthening their processing capacities, the availability of raw cashewnuts for import will be reduced drastically in future. Hence, it has become inevitable to increase the raw cashewnut production in the country to maintain leading position in the international market and trade.

It has been estimated that the requirement of raw cashewnuts will be 25.0 lakh tonnes by 2030 and would touch the mark of 45.0 lakh tonnes of raw cashewnuts by 2050 (Fig.1). This target can be achieved by enhancing productivity of cashew to 2.5 to 3.0 t/ha by

harnessing the power of science as well as area expansion in prospective locations. The low yielding cashew plants of senile and non-descript origin need to be replaced with cashew grafts of high yielding varieties along with adoption of improved production technologies. It is essential that India should keep pace and meet the requirement of raw cashewnuts for cashew processing industries and achieve self sufficiency. There is a need to keep up the same tempo up to 2050 and beyond.

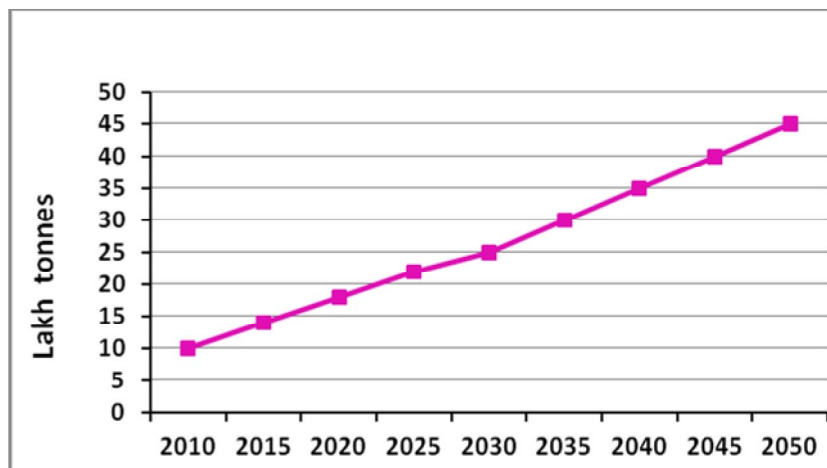


Fig. 1: Projection of raw cashewnut requirement

Cashew has adapted to the Indian climatic conditions after its introduction to India and is presently grown in an area of about 9.91 lakh hectares with a production of 6.92 lakh tonnes. The average productivity level is 749 kg/ha (2011-12) and it ranges from 455 kg/ha in Goa to 1282 kg/ha in Maharashtra. Maharashtra occupies 18 per cent of the total area in the country but it contributes 32 per cent of the total production in 2011-12 (Figs. 2-4).

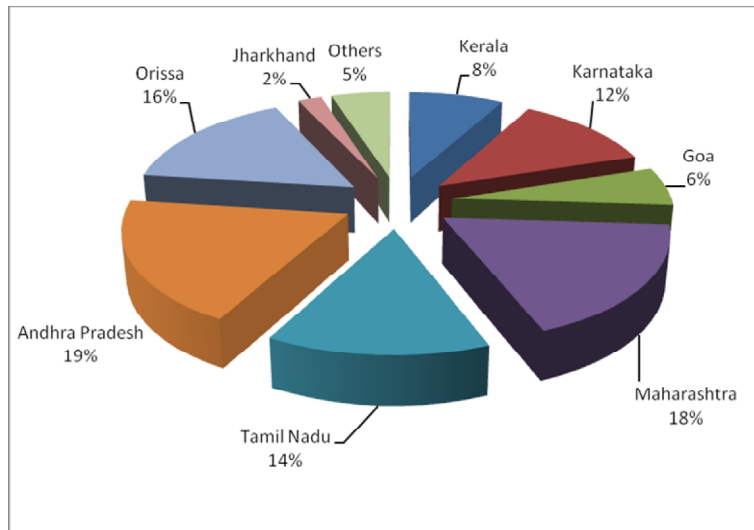


Fig. 2: Per cent distribution of cashew area in different states : 2011-12

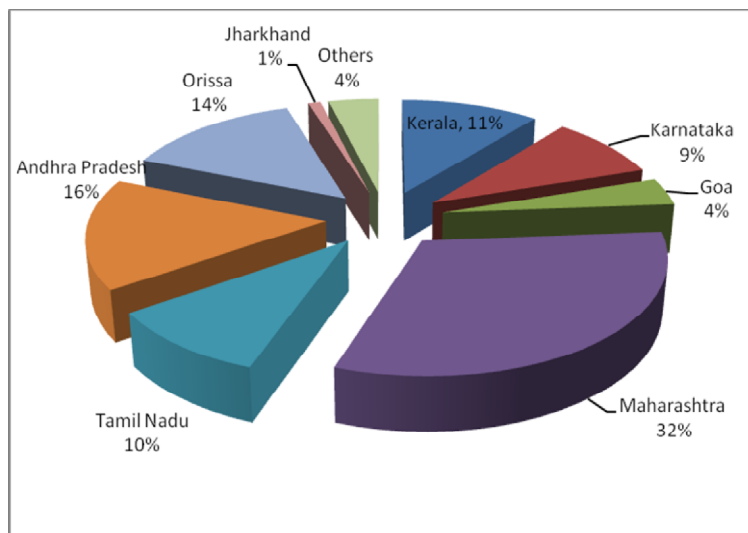


Fig. 3: Per cent distribution of cashew production in different states : 2011-12

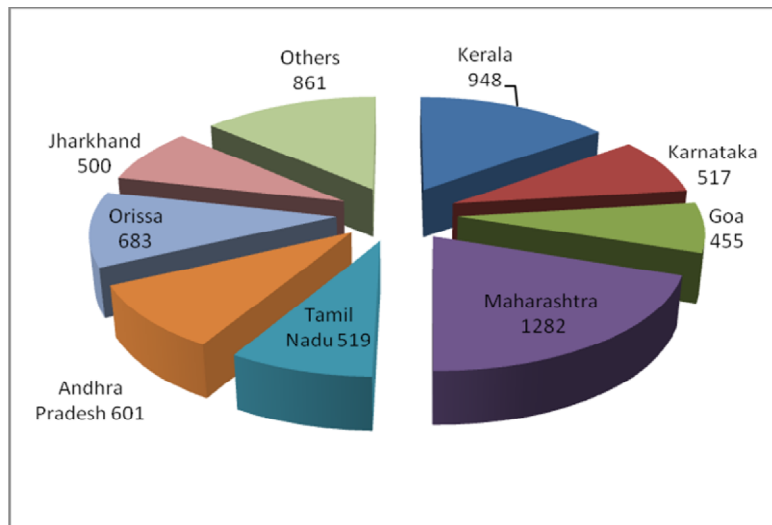


Fig. 4: Productivity of cashew (kg/ha) in different states : 2011-12

Globally, cashew is grown in more than 30 countries and as per the latest statistics (FAO, STAT- 2011), India occupies large area (20%) followed by Ivory coast, Brazil, Indonesia, Vietnam, Nigeria, Benin, Guinea-Bissau, Mozambique and Philippines (Fig.5). The highest production was from Vietnam followed by Nigeria, India, Ivory Coast, Brazil, Indonesia, Philippines, Guinea-Bissau, Benin and Mozambique (Fig.6). India was enjoying an unparalleled and unchallenged monopoly in the production, processing and marketing of cashew in the world. As other cashew producing countries acquired the know-how of processing and entered the international market, currently the India's share in the International market has shrunk to 30 per cent. On the other hand, the domestic consumption in India has gone up beyond imagination and made India as the largest consumer of cashew in the world. Hence, India has to gear up to meet the demands of tomorrow and adopt strategic planning both on short and long term basis.

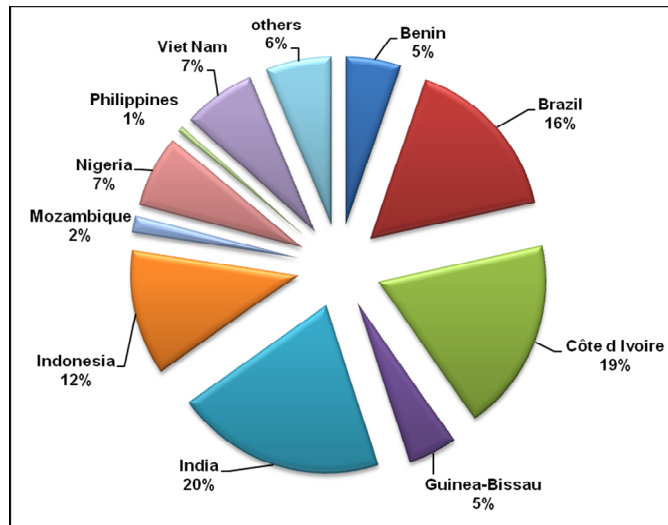


Fig. 5: Per cent distribution of cashew area in different countries : 2011

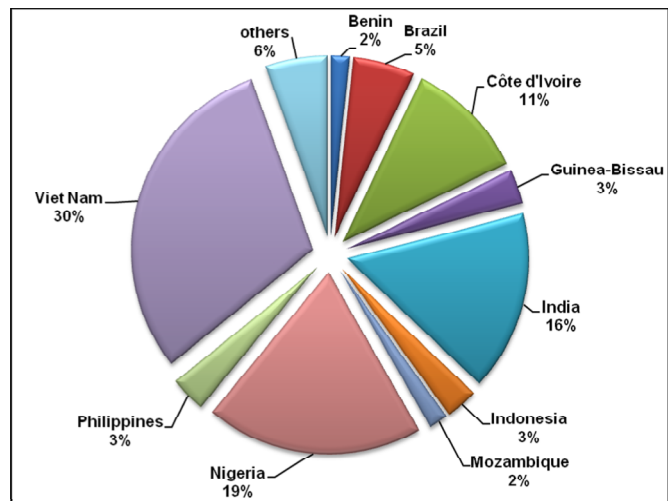


Fig. 6: Per cent distribution of cashew production in different countries : 2011

In India productivity level is not increasing at the expected rate over the last few years. This needs serious attention to identify the gaps and reorient our approaches to meet the needs of future. Keeping in view 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 2050 - DCR** has been prepared. In this context, there is an urgent need to address the emerging issues and to develop roadmap for achieving high productivity of cashew in accordance to its true potential.

2. CHALLENGES

Cultivation and processing of cashew is expanding rapidly in many parts of the world. The South East Asian countries namely, Vietnam, Indonesia and Thailand have taken up cashew cultivation on a large scale. Brazil has initiated well organized state supported programme of cashew development. Research efforts are also in progress in Brazil (EMBRAPA - National Research Centre for Cashew, Fortaleza, Ceara State), Tanzania (Tanzanian Agricultural Research Organization Research Institute (TARO-RI), Naliendele (Mtwara) ; 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, India may not be able to further import raw cashewnuts from those countries to meet the domestic demand. This shortfall may partially be met by importing raw nuts from some South East Asian countries, which are yet to develop proper processing facilities.

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 are receiving from international organizations for research on cashew is also of concern to India. While in India cultivation of cashew is generally under low fertile soils, the South East Asian countries are taking up cashew cultivation in the best areas suitable for higher production.

In India, research and development efforts on cashew have resulted in achieving 5.3 times increase in production and 3.0 times increase in area from the base level of 1972-73 (Fig.7).

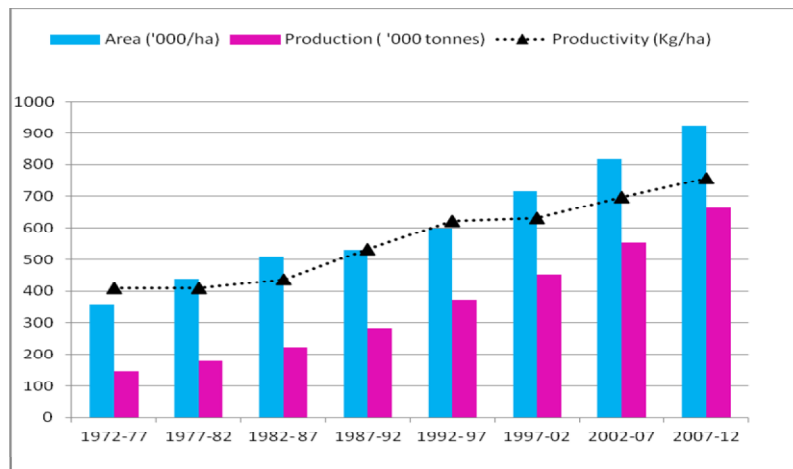


Fig.7: Area, production and productivity of cashew at 5 years intervals (1972-2012)

This has been possible due to technological interventions and area expansion. Yield gap analysis revealed that the optimum production potential of cashew is yet to be tapped. Wide differences in yield existed between potential and actual yields. Similarly, there is a broad gap between potential and realizable yields. The challenges before us are much greater than before, and have to be addressed with strategic approaches utilizing innovations in science and technology. Past achievements are testimony for our success in addressing the challenges, which may need investment and concerted efforts in an integrated manner. Science and technology oriented development has been a driving force to face these challenges. Cashew research needs much more attention for conservation of genetic resources, utilization of wasteland, employment opportunity, reversing the declining profitability, cashew diversification etc.

Global climate change is now a reality and a major challenge for agricultural production systems. Climate change may pose problem for cashew cultivation since cashew is grown in ecologically sensitive areas such as coastal belts, hilly areas and areas with high rainfall and humidity. Cashew is generally grown as a rainfed crop and vagaries of weather may affect production from drylands, thereby influencing the stability of the nut production in the country. Strategic research on rainfed cashew may be a priority area, to insulate the farmer from high risk-proneness of dryland farming. Watershed development for raising productivity of rainfed cashew, insurance cover for risk-prone areas and marketing facilities are some of the areas which need more attention.

Development of promising technologies and their efficient transfer holds the key to increase the productivity and thereby increasing the raw cashewnut production in the country. However, challenges of low average national productivity of cashew needs to be addressed. It is also important to develop and expand domestic market for cashew kernels so that good price can be ensured for the raw nuts and thereby encouraging the farmers to grow cashew.

3. OPERATING ENVIRONMENT

The Directorate of Cashew Research (DCR) (former National Research Centre for Cashew) was established in 1986 at Puttur, with the main purpose of giving thrust on increasing the production and productivity of cashew in the country. Since its inception, it has made major strides in enhancing the production and productivity of cashew. This Directorate serves as a national repository for cashew germplasm and a clearing house for research information on cashew. The impact of research efforts of DCR is now visible with the adoption of new varieties, production technologies and high demand for quality planting materials by the cashew farmers. All India Coordinated Research Project on Cashew (AICRP-Cashew) was also initiated as an independent project in 1986 with the main purpose of giving thrust on increasing the production and productivity of cashew in the country by addressing location specific problems. Since then India has progressed substantially in research front on cashew and the significant achievements in the area of Crop Improvement, Crop Management, Crop Protection, Post – Harvest Technology and Transfer of Technology are discussed hereunder. There is need to utilize available technologies for enhancing raw nut production. The important achievements are:

- Directorate of Cashew Research has country's largest cashew germplasm collection of 528 accessions maintained at its National Cashew Field Gene Bank (NCFGB). A total of 433 cashew accessions have been assigned with National Collection numbers (IC Nos).
- The Conservation Block of Gene Bank has been established with 362 evaluated accessions by planting four plants of each accession.

- A total of 41 cashew varieties (28 selections and 13 hybrids) have been developed and released in the country for cultivation in varied agro-ecological situations by Directorate of Cashew Research and centres of AICRP on Cashew. In addition, the hybrids, H-66, H-68, H-43, H-125 and H-126 have been found promising for yield and bold nut characters.
- The varieties released by DCR viz., NRCC Selection-2 and Bhaskara are medium nut types with high yield and recommended for cultivation in Karnataka. These varieties exhibited better yield performance in other cashew growing regions of the country as well.



Fruits of variety : **Bhaskara**

- Regeneration of cashew from the seedling explants (nodal cultures) has been standardized.
- Micrografting technique for *in vitro* multiplication of cashew has been standardized.

- Protocols have been standardized for characterization of released varieties and cashew germplasm accessions using RAPD, ISSR and SSR markers.
- The standardization of softwood grafting technique in cashew both at Directorate of Cashew Research and AICRP on Cashew has enabled commercialization of graft production. Over 150 lakh cashew grafts are being produced annually by this method both by government and private sectors.



Production of quality planting material

- High density planting is highly economical to augment the yield per unit area. Planting at a spacing of 5m x 4m – 500 plants/ha not only increased yield by four folds up to 6 years and 2.27 folds up to 12 years but also reduces weed growth and soil temperature.
- The Directorate has demonstrated the advantage of growing intercrops like pineapple, turmeric, brinjal, chillies and amorphophallus profitably in cashew orchards.

- Glyricidia grown as an intercrop during initial years contributed 5.75 t/ha of dry matter, equivalent to 186 kg N, 40.8 kg P₂O₅ and 67.8 kg K₂O/ha. The yield of cashew increased by 50 per cent when glyricidia and sesbania were raised as green manuring crops compared to control.
- High density planting at a spacing of 4m x 4m (625 plants/ha) is better than normal spacing of 8m x 8m (156 plants/ha) resulting in 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.
- Soil and water conservation techniques like modified crescent bund or staggered trenches with coconut husk burial treatments helps in conserving soil moisture, reducing the annual runoff / soil loss and increasing the nut yield. Individual tree terracing with crescent bund is the best soil and water conservation measure in slopy lands.



Crescent bund as soil and water conservation measure

- Recyclable Cashew Biomass (RCB) can be converted to vermicompost by utilizing the earthworm, *Eudrillus* sp. The recovery is 65-75 per cent within three months.
- Crop suitability studies for cashew using GIS indicated that the productivity of cashew is higher in regions upto 750 m above MSL, mean annual rainfall of 600 to 1500 mm, mean annual temperature of 22.5 to 27.5°C and minimum temperature of 10 to 22°C.
- Cashew stem and root borers (CSRB) are one of the major pests of cashew and presently, removal of pest stages from infested trees followed by insecticidal treatment viz., chlorpyrifos (0.2%) is recommended along with phytosanitation for managing the CSRB.
- The entomopathogenic nematodes (EPN) viz., *Heterorhabditis bacteriophora* and *Steinernema feltiae* were encountered indigenously in the cashew ecosystem. The EPN species *Heterorhabditis indica*, *Steinernema abbasi* and *Steinernema bicornutum* were found to be virulent in the soil upto 150 days.
- For the management of the other major pest tea mosquito bug (TMB) need based sprays with insecticides such as L-cyhalothrin, profenophos and triazophos are found effective.
- The phenomenon of phenological evasion of tea mosquito bug shown by some genotypes such as Goa 11/6 (later released as variety 'Bhaskara') may be advantageously used in formulating breeding programmes to escape severe infestation by TMB.



Tea mosquito bug damage on shoots

- Mineral composition of defatted cashew kernel flour, testa and cashew apple varied among released varieties. Blending cashew apple pomace with defatted flours of either cashew or almond could improve the mineral content.
- Cashew apple powder lipids are rich in unsaturated fatty acids and the major fatty acids are palmitoleic and oleic acids. Antioxidant activity in the cashew apple is associated with tannin, phenols, sugars, ascorbic acid and amino acids. Treatment of cashew apple with salt reduces the tannin content of cashew apple powder.
- Processing parameters for farm level scale processing are optimized in order to improve whole kernel recovery to improve economic benefits to cashew farmers.
- A dual mode dryer has been developed to dry raw cashewnuts affected by rain and enhance its storability.
- A cashew shell cake (CSC) based up-draft gasifier suitable for applications needing thermal requirement of 10-12 kW has been developed.

- A compact type mechanized drum roasting machine for raw cashewnuts is developed and processing parameters have been optimized for better kernel quality for various sized nuts.
- Assessed the impact of transfer of technology (TOT) efforts and strategies have been formulated for their refinement.

The production of cashew has increased from 1.30 lakh tonnes during 1972-73 to 6.92 lakh tonnes during 2011-12. With the nutritional awareness and the stable price in the international market for cashew kernels, the trend in the consumption of cashew kernels is expected to increase in the coming years. 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. Another advantage for the cashew export is that none of the major cashew importing countries has cashew cultivation. India also has the benefit of a well-structured development agency viz., Directorate of Cashewnut and Cocoa Development (DCCD), Kochi for cashew related activities besides state line departments. Cashew production at the national level can take the advantage of both research as well as, development network established in the country to further boost the crop prospects in the years to come. Cashew Export Promotion Council of India (CEPCI), Kochi established in 1955 caters to the requirements of cashew exporters with respect to international trade. Further, in the international market, demand for Indian cashew kernels is increasing as they are rated to be the best in terms of quality.

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 41 varieties released so far, 13 varieties have the yield potential of 2.0 tonnes and above per hectare. As large planting material is needed both for area expansion and

replanting programmes, certified regional nurseries have been established. These nurseries have the capacity of producing over 150 lakh cashew grafts annually, which will help the country to become self sufficient in raw cashewnut production and continue to maintain a leading position in the international cashew trade in spite of stiff competition from other cashew growing countries.

The stable price of the cashew kernels in the international market is a main opportunity for cashew cultivation in India and the recent increase in the price of raw cashewnut would encourage the farmers to expand the area under cashew. The domestic market is growing rapidly and also various food products having cashew are being aggressively marketed which ensures a continuous demand for cashew kernels. Cashew kernel compares well with other tree nuts and has high protein, minerals and unsaturated fatty acids. By developing cashew kernels with higher nutritive value, it is possible to exploit the international demand of quality conscious consumers.

The technologies developed based on new research strategies would help in enhancing the productivity of cashew resulting in increased production and lesser dependence on import of raw nuts with self reliance on indigenous raw nuts required for processing. In addition to this, research on utilization of by-products particularly research on cashew apple and cashewnut shell liquid are also being carried out by various Research Institutes. Product diversification efforts have resulted in enhanced trading of cashew products and market for cashew products as 'health food' is attracting the consumers across the globe. Intensification of research on these lines will definitely add value for effective utilization of this potential crop.

4. OPPORTUNITIES

Besides degraded lands of sub-tropical / coastal region, large area suitable for cashew cultivation is available in various parts of the country which can be utilized for area expansion of cashew. Cashew is known to perform well even under moderate management conditions. Raw cashewnuts can be stored over a long period unlike other perishable horticultural produce and sold opportunely to get higher price. Establishment of cashew processing units can generate employment opportunity for women and cashew apple products can promote small scale cottage industries at farm level.

Genetic improvement of cashew, improved crop management practices, integrated pest management approaches, water, nutrient and soil resource management and farmer friendly public policies are the key strategies to increase productivity of cashew. The advances made in recent past in cashew production technology need to be emphasized. However, more research efforts are needed in order to generate cost effective cashew production technology. In addition, increase in productivity and expansion of area under cashew is another strategy for enhancing raw nut production in the country. Increasing productivity is the main aim of research activities at this Directorate and under the AICRP-Cashew set-up.

Further, research should focus on modifying the plant architecture and designing new ideotypes which can utilize solar energy, nutrients and water more efficiently. It is important to improve the efficiency of all production inputs viz., water and nutrients, minimize the losses caused by pests, diseases and weeds to achieve sustainable increase in cashew productivity along with effective post-harvest handling to ensure produce of superior quality. Emphasis should be laid on integrated nutrient management, efficient

management of water, soil health management, integrated pest management, weed management etc.

There is an immediate need for achieving quantum jump in cashew production in order to meet the raw nut requirement of the cashew industries by increasing productivity. The cashew production can also be increased by area expansion under high yielding varieties in collaboration with various development agencies. Various technological approaches such as high yielding varieties, high density planting, drip irrigation, optimum use of fertilizers etc., are being evaluated for their suitability in the various cashew growing tracts and being recommended to enhance productivity. Research strategies for increasing productivity with priority are given in Annexure 1.

The foremost constraints limiting the cashew productivity in the country are:

- Large tracts having non-descript and seedling origin senile plantations of cashew in State Cashew Corporations and Forest Corporations.
- The lands unsuitable for other crops are utilized for cashew cultivation. These are usually degraded lands with poor soil fertility.
- Farmers are not fully aware of the latest cashew production technology.
- Non adoption of recommended package of practices to the extent required.

- Absence of compact and dwarf high yielding varieties for realizing its full potentiality of high density planting technology.
- Though cashew apple production in the country is about eight to ten times that of nut production, most of the cashew apple is not utilized in India except in Goa where a small quantity of cashew apple is utilized for 'feni' preparation.

Possible solutions and strategies to overcome cashew production constraints are:

- Increasing productivity by adopting improved cashew production technologies.
- Massive replanting programme to replace senile and unthrifty orchards.
- Development of cost effective cashew production technologies.
- Expansion of cashew area both in traditional and non-traditional areas.
- Development of compact and dwarf high yielding cashew varieties suitable for high density plantation.
- Effective pest management strategies against major insect pests and pests of regional importance.
- Development of cashew based integrated farming systems.

5. GOALS/TARGETS

In order to regain and maintain India's leading position in the international market and trade it is of utmost importance to increase the raw cashewnut production in the country. This can be achieved by enhancement of productivity in existing plantations as well as by bringing the new areas under cultivation both in traditional and non-traditional areas of the country. It has been estimated that the requirement of raw cashewnuts will be 25.0 lakh tonnes by 2030 and would touch 45.0 lakh tonnes of raw cashewnuts by 2050. The major step to meet this challenge would be to establish sound research programmes through basic and strategic approaches in the areas of Crop Improvement, Crop Management, Crop Protection and Post-Harvest Technology. There is an urgent need to establish linkages with leading research institutions both within the country, as well as, in foreign countries for achieving the desired goal. In addition, public-private partnership and participatory approaches need impetus. The focus for the future would be:

- **Adequate cashewnut production to attain and maintain self sufficiency.**

There is wide gap between raw cashewnut processing capacities of the industries established in the country as well as, the actual raw cashewnut production. In order to meet this deficit, every year, India imports nearly 50 per cent of the required raw cashewnuts from African and South East Asian countries. The availability of raw cashewnuts for import has been reduced drastically as these countries have strengthened their processing industries. Hence, it has become inevitable to increase the raw cashewnut production in India to attain and maintain self sufficiency. Further, it would enable India to maintain leading position

in the international market and trade. Research efforts are to be concentrated keeping this vital goal in mind.

- **Improve livelihood of cashew farmers with increased income levels.**

Cashew is generally grown in slopy land and in the soils with poor fertility status. The cultivation of this crop is taken up mostly by poor farmers or the farmers without any irrigation facilities. In fact, through cashew cultivation, the degraded soil can be converted into healthy soil leading to higher yields thereby improving the economic status of the cashew farmer.

- **Enhanced employment opportunities through value addition.**

Cashew industries already employ a large number of rural women for various steps involved in processing. Research undertaken at several research organizations have clearly established that various value added products can be prepared out of cashew kernel as well as cashew apple. There is an excellent scope for establishing industries focusing on value addition once the production of raw cashewnuts is increased by many folds. This would definitely boost employment opportunities especially for skilled rural women.

- **Achieving nutrition security in the scenario of growing population.**

Cashew kernel is mini store house of protein, carbohydrate and fat with right proportion of saturated, mono unsaturated and poly unsaturated fatty acids. It also contains vitamin E which improves immunity by virtue of being a naturally occurring antioxidant. The purchasing capacity of Indian population is increasing rapidly and there could be demand for huge quantity of cashew kernel available in the domestic market in future. The consumption of nutritious cashew kernel could surely bring about nutrition security for growing population.

6. WAY FORWARD

Cashew being a primarily export-oriented crop; assured market stability and international market prices will influence the establishment of cashew as an horticultural crop in the country. 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 was placed at the base of the Diet Pyramid along with fruits, vegetables and legumes encouraging daily consumption, in the new version developed by the World Health Organization. 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 for cashew kernels can be expected to increase in near future.

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 strong competitors in the years to come. As mentioned earlier, already 9.91 lakh ha area is under the cashew and further expansion of the area by enterprising farmers should be encouraged. The target for raw cashewnut production by 2030 is 25.0 lakh tonnes and by 2050 is 45.0 lakh tonnes. The strategy is to take up fresh planting or replanting with grafts of high yielding varieties / hybrids in newer areas and areas having senile and unthrifty cashew plantations raised from seedling origin. These areas identified for replanting have been shown to be suitable for cashew cultivation over several years and have a lesser degree of soil degradation under crop cover for a longer

period. It is crucial to disseminate the technologies developed by the research centers, especially the high yielding varieties with export grade kernels and other preferred traits. It is also necessary to develop improved package of practices which is cost-effective, so that the production cost can be reduced and processed kernels can be priced competitively in the international market. In order to reduce and rationalize the pesticide usage, development of suitable IPM strategies for major pests of cashew comprising of field tolerant varieties and pheromone/ kairomone technology is essential.

Cashew apple is not being utilized fully and the same can be utilized to produce industrial alcohol, ethanol / bio-fuel for use in combination with petrol in automobiles and other machinery, besides preparation of various culinary products. Intensifying the production of another by-product viz., Cashewnut 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 targeted drug delivery which can be exploited to the fullest extent possible. Cashewnut is not a perishable horticultural commodity and can be stored without deterioration in kernel quality for a maximum period of nine months. Cashew farmers can sell the nuts as and when price is profitable and need not going for distress sale. High density planting in cashew is a key approach for augmenting productivity. However, high density planting needs suitable dwarf and compact cashew varieties so as to harness solar energy without overlapping of canopy. Fresh efforts are needed at Government level through Memorandum of Understanding (MOU) to obtain cashew types having dwarf and compact canopy with high yield. It is also reported that Brazil has unique cashew apple types suitable for fresh consumption without much astringency. In the MOU / Work Plan, the unique cashew apple types can also be included for introduction to India.

Research programmes are contemplated at Directorate of Cashew Research Puttur, under Crop Improvement, Crop Management, Crop Protection, Post Harvest Technology and Transfer of Technology as detailed hereunder to translate the perspective into reality.

Crop Improvement

- Enrichment of National Repository of Cashew Germplasm.
- Need for well established protocol for exchange of cashew germplasm, improved varieties and hybrids between India, Brazil and other countries.
- Characterization, evaluation and valuation of cashew germplasm.
- Utilization of wild cashew types for introgression of desirable traits in newer varieties.
- Identification of tolerant source for the major pests of cashew viz, tea mosquito bug and cashew stem and root borer.
- Development of dwarf cashew varieties suitable for high density planting.
- Identification of tolerant source for abiotic stress viz., drought, salinity, waterlogging, low temperature etc.

- Development of varieties in the scenario of climate change using bio-technological tools and other advanced techniques.
- Development of high yielding varieties with improved biochemical quality.
- Development of varieties with bigger apple size and less astringency to support and enhance production of bio-fuel and other value added products.
- Identification of molecular markers linked to economic traits for marker aided selection.
- Saturation of genetic maps.
- *In vitro* conservation of germplasm for long term storage by cryopreservation techniques.
- Evolving cashew genotypes using genetic engineering techniques for various desirable growth and yield characteristics.
- Creation of gene library and saturation of genetic maps.

Crop Management

- Identification of suitable rootstocks.
- Standardizing canopy architecture for various planting densities.

- Usage of growth regulators for enhancing productivity.
- Studies on synchronized ripening of cashew apple.
- Nutrient dynamics, site specific nutrient management and development of nutrient diagnostic norms.
- Improving productivity and quality by increasing input use efficiency in different agro-ecological regions.
- Identification of sustainable cashew based farming system.
- Development of organic farming modules for domestic and global markets.
- Standardization of fertigation and critical regime of water management.
- Documentation of nutrient deficiency / toxicity symptoms.
- Investigations on identifying causes for yellow leaf spot of cashew and suggesting remedial measures.
- Development of decision support system (DSS) and yield forecasting models in cashew.
- Assessing impact of climate change on cashew and development of technologies for climate change, adaptation and mitigation of green house gas (GHG) emissions.
- Development of climate resilient agro-techniques in order to suit unfavourable abiotic conditions.

Crop Protection

- Development of eco-friendly IPM strategies for the management of major pests of cashew involving kairomone or pheromone technology.
- Utilization of bio-control agents such as entomo-pathogenic pathogens, parasitoids etc., for the effective management of pests of cashew.
- Development of acoustic equipment for detection of pest activity in case of borers.
- Documenting the bio-diversity of fauna and their role in cashew ecosystem.
- Standardization of mass rearing of CSRB, flower and fruit pests and their natural enemies.
- Analysis of pesticide residues in cashew produce and cashew ecosystem to address concerns pertaining to food quality standards.
- Monitoring of new pests and diseases in the scenario of climate change and development of models for forecasting the pest incidence.
- Etiology and transmission studies on prominent diseases.

Post Harvest technology

- Mechanization of cashewnut processing with modern improved technologies.
- Development of non-thermal solar based, eco-friendly cashewnut processing system.
- Improving the extraction technique of anacardic acid from cashewnut shell.
- Development of cost effective system for preparation of bio-fuel from cashew apple.
- Alternate utilization of byproducts of cashew industry viz., cashew apple pomace, cashew shell, cashew testa and cashew rejects for better economic returns.
- Development of protocols for value added products.

Transfer of technology

- Utilizing advances in ICTs for wider farmer reach and efficient transfer of advanced cashew production technologies.
- Identification, analysis and popularization of sustainable cashew based farming systems for different cashew growing areas of the country.
- Promote innovations and improve human resource capacity by involving all stakeholders in the cashew supply chain.

- Capacity building for farmers, line-departments and extension personnel.
- Development of software to cater to agro - meteorology / weather based advisory for cashew cultivation.
- Constraint analysis in cashew cultivation.

ANNEXURE-1

Strategic Frame Work

Goal	Approach	Performance measure
Genetic resource management	Broadening of genetic resources.	Number of diverse types collected.
	Conservation, evaluation, characterization and cataloguing of both exotic and indigenous germplasm accessions.	Development of cashew germplasm data base for sharing information.
	Collection of cashew genotypes tolerant to biotic and abiotic stress.	Identification of tolerant types to tea mosquito bug /cashew stem and root borer (CSRB), drought and saline soils etc., and related species and genera from cashew growing regions both within and outside India.
	Molecular characterization of germplasm through DNA (ISSR / SSR) and isozyme markers	Diversity, estimation and finger printing.
	Establishment of long-term conservation field block of germplasm.	Conservation of germplasm accessions under field conditions, National Cashew Field Gene Bank (NCFGB).

	Promote access to cashew germplasm.	Material and information sharing among research centres in India.
Genetic improvement of cashew	Introduction of dwarf and compact cashew types from Brazil and African countries through NBPGR.	Number of exotic collections introduced from Brazil and other cashew growing countries.
	Evolving of dwarf and compact cashew varieties.	Development of varieties suitable for high density planting system.
	Evolving varieties with higher 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.	Development of varieties with desired traits. Reduced pesticide use, environment and food safety. Expansion of area under cashew.
	Genetic enhancement of cashew through prebreeding for intriguing characters.	Number of material utilized for breeding activities.
Application of biotechnology tools in cashew	Identification of molecular markers linked to economic characters in cashew and construction of genetic maps.	Number of markers identified, validated and genetic map developed.

Improving soil health, nutrient and water use efficiency and climate risk management	Management strategies to improve nutrient and water use efficiency.	Quantification of nutrient and water use efficiencies for enhancing productivity of different varieties.
	Enhanced input use efficiency.	Reduced cost of production and better returns.
	Diagnosing micronutrient related constraints to productivity and sustainability.	Micronutrient management for sustainable cashew productivity.
	Nutrient dynamics in soils and plants.	Establishment of nutrient norms and improvement of soil quality.
	Management options for organic farming in cashew	Development of techniques and standardizing the inputs for organic farming.
	Approaches for managing climate change in cashew.	Development of adaptation and mitigation strategies for climate change effects.
Enhancing cashew productivity through horticultural interventions	Screening of rootstocks for dwarfing and biotic and abiotic stresses	Identification of rootstocks having dwarfing effect and resistance to biotic and abiotic stresses.
	High density planting to increase productivity of cashew.	Standardize the high density planting method for cashew.

	Canopy architecture management to suit the requirement of different plant densities and system of planting.	Pruning techniques for different plant densities and system of planting.
	Manipulation of canopy size through chemical interventions.	Identification of chemical agents for canopy management
	Rejuvenation of old cashew plantations /orchards.	Standardizing technique for enhancing productivity of unproductive and less productive orchards.
	Approaches for Integrated cashew based farming system	Development of management practices for Integrated cashew based farming system.
Standardization of alternate techniques for management of pests and minimizing the usage of pesticides.	Employing kairomones, pheromones and Entomopathogenic Nematodes for effective and economic control of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB).	Integrated pest management (IPM) strategies recommended for the management of major insect pests of cashew.
	Standardization of mass rearing of CSRB, flower and fruit pests and their natural enemies and semi-synthetic diet (SSD) for CSRB.	Developing standardized mass rearing techniques for the important pests of cashew and their natural enemies.

	Etiology and transmission studies on yellow leaf spot disease.	Confirming the etiology and transmission of yellow leaf spot disease.
	Investigations on panicle drying (in absence of TMB).	Development of technique for panicle drying.
	Analysis of pesticide residues in cashew produce and cashew ecosystem to address concerns of food quality standards.	Determination of 'safe period' for different insecticides
Improving cashew processing system through mechanisation	Modifications / altering existing processing machinery for better efficiency	Development of efficient cashew processing machinery.
Optimisation of processing parameters for better economic benefits	Optimization of processing parameters related to various mode of processing suitable for Indian conditions for better economic returns.	Achieving high performance of the processing system.
	Development of low cost moisture meter for raw nut.	Assessing quality of raw cashewnuts.
	Reduced post harvest losses and waste utilization	Better profitability and employment generation.
	Institute ~ Industry collaboration to resolve problems on methods of processing.	Providing trouble-shooting for the stakeholders.

	Development of protective measure to overcome the problem of Cashew Nut Shell Liquid (CNSL) affecting hands of labourers engaged in shelling operation.	Safety of labourers engaged in cashew processing.
Value addition to cashew and its by-products	Developing technologies for alternative use of by-products of cashew processing industry such as Cashew Nut Shell Liquid (CNSL), cashew shell cake , kernel testa and cashew apple pomace.	Development of profitable value added products.
	Exploring the possibility of production of industrial alcohol / bio-fuel from cashew apple.	Alternate use of cashew by-products.
Development of cashew sector through efficient transfer of improved production technologies.	Production and supply of quality planting material of improved cashew varieties.	Intensified extension efforts to bridge the gap between actual yield and potential yield.
	Utilizing and standardizing mass media based Transfer of Technology (TOT).	Developing appropriate mass media based TOT

	Case studies on profitable cashew based cropping systems for popularization.	Number of adoptions of profitable cashew based cropping systems
	Utilizing advances in ICTs for wider farmer reach and efficient transfer of advanced cashew production technologies	Enhanced area /number of farmers covered and adoption rate.
	Area expansion through increased number of demonstration plots and demand based input supply.	Better adoption of improved varieties in farmers' field.
	Cashew based farming systems for different cashew growing areas of the country.	Cashew based farming systems identified and popularized for different cashew growing areas of the country.
	Promote innovations and improve human resource capacity by involving all stakeholders in the cashew supply chain	Innovations identified and HRD/Trainings conducted for trainers and farmers.



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