Cashew Production Technology 2015

Lecture Notes Series 23

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DCR

ICAR-Directorate of Cashew Research
Puttur - 574 202, Dakshina Kannada
Karnataka

Training on

CASHEW PRODUCTION TECHNOLOGY

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ICAR-Directorate of Cashew Research
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CASHEW CULTIVATION IN INDIA: ISSUES AND CHALLENGES

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Introduction

Though, cashew (*Anacardium occidentale* L.), is an exotic horticultural crop brought to India by Portuguese travellers in 16th Century but now adapted well in Indian conditions. It is grown along the coastal regions of Maharashtra, Goa, Karnataka and Kerala in the West Coast and Tamil Nadu, Andhra Pradesh, Odisha and West Bengal in the East Coast. It is spreading in non-traditional areas such as Bastar region of Chhattisgarh and Plain regions of Karnataka, Gujarat, Jharkhand and in NEH region. Due to its high nutritional value and increasing affordability by the consumers, demand for cashew continues to increase both in India and in foreign countries. During 2012-13, total production of cashew in the country was 7.28 lakh tonnes from 9.82 lakh ha of land with a productivity of 772 kg/ha (Fig. 1). Moreover, the productivity of cashew nut in India is very. There is a wide gap between potential productivity and present productivity. The major factors for low productivity are: the large plantations under seedling origin, poor orchard management practices and severe incidence of tea mosquito bug (TMB) and cashew stem and root borer (CSRB).

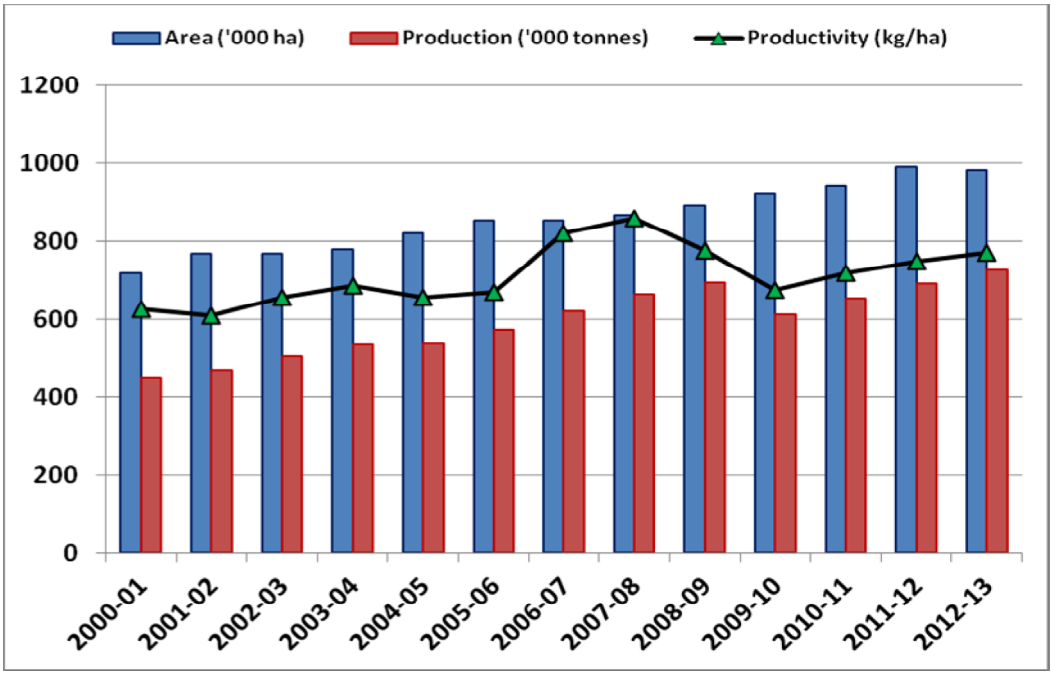

Fig. 1. Area, production and productivity of raw cashew nut (2000-01 to 2012-13)

Production system management

(i) Establishment of cashew orchard

Though, cashew is grown in almost all types of soils, it performs better in well drained, brown forest soils, red sandy loam and light coastal soil with a high water holding capacity and rich in organic matter. Cashew is a deep-rooted crop with its active roots concentrated in the first 1 m depth of the soil and 2 m radius around the trunk of the tree. Therefore, soil should be minimum 1.5 m deep without any hard pan which obstructs root growth. While selecting land for cashew, soils with salinity/ alkalinity or water logging should be avoided. The selected land should be cleared of shrubs/ vegetation before digging pits. The pits of 60 cm x 60 cm x 60 cm are to be opened at a spacing of 7.5m x 7.5m or 8m x 8m for cashew which gives a tree density of 175 and 156 trees/ha, respectively. High density planting at 4m x 4m giving a tree density of 625 trees/ha in the initial years and subsequently thinning in stages to reach a final spacing of 8m x 8m is also practiced in some areas. High density planting of cashew is more suitable in less fertile areas. The size of pits can be increased upto 1m x 1m x 1m in soils with hard pan or hard laterite substratum. Opening the pits along the contour line is preferred in slopy areas. The pits have to be filled with mixture of top soil, compost (10 kg) or poultry manure (2 kg) and rock phosphate (200 g). A small channel above the pit is opened to divert water to the sides during rainy season in slopy lands. The runoff water should not accumulate in the pit which causes water stagnation during rainy season.

Planting of grafted plants is usually carried out during the monsoon season (July-September). The polythene bag (containing graft) covering the root and soil is to be removed carefully and the graft with ball of earth intact is to be separated. The graft is to be placed gently in the centre of the pit where soil is scooped out and cover with soil and press gently. The graft is to be planted in such a way that the graft union is above the soil level. Sprouts if any below the graft union may be removed with the help of sharp knife. Plastic ribbon covering the union is removed if not done already. Mulching should be done at the base around the plant to conserve soil moisture and also to suppress weed growth. Frequent watering is required during post monsoon phase.

(ii) Selection of varieties

With the concerted efforts of DCR, Centres of AICRP-Cashew and SAUs, a total of 42 cashew varieties (29 selections and 13 hybrids) have been developed and released in the country for cultivation.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. Twenty-one varieties have kernels with export grade (W 180 to W 240). The varieties recommended for adoption in different cashew growing states are given below:

State	Recommended varieties
Andhra Pradesh	BPP-4, BPP-6 and BPP-8
Goa	Goa-1, Goa-2, Vengurla-1, Vengurla-4, Vengurla-6 and Vengurla-7.
Karnataka	NRCC Sel-2, Bhaskara, Ullal-l, Ullal-3, Ullal-4, Vengurla-4, Vengurla-7, Madakkathara-2, Chintamani-1 and Chintamani-2.
Kerala	Madakkathara-I, Madakkathara-2, K-22-I, Kanaka, Dhana, Priyanka, Amrutha and VRI-3.
Maharashtra	Vengurla-l Vengurla-3, Vengurla-4, Vengurla-6, Vengurla-7 and Vengurla-8.
Odisha	Bhubaneswar-I, BPP-8 and Dhana.
Tamil Nadu	VRI-1, VRI-3 and VRI H-1
West Bengal	Jhargram-I, Bidhan Jhargram-2 and BPP-8
North Eastern States	Ullal-3, Ullal-4, Vengurla-1 and Vengurla-4

(iii) Production of Quality planting material

Being a cross pollinated crop, the seedlings raised orchards show variation with respect to yield, nut size, apple colour and several other characters. Hence, vegetative propagation is adopted in cashew as vegetatively propagated clonal progenies are genetically identical to the mother plant and give relatively more uniform yield and come to fruiting earlier. Of the different methods of vegetative propagation, softwood grafting was found to be the best for vegetative propagation of cashew. Production of planting material of high yielding varieties through softwood grafting technique has been a great success story in cashew and has made tremendous impact in improving cashew productivity. There are over 100 Regional Cashew Nurseries, which are coming under both public and private sector. Farmers are always advised to procure planting materials from accredited nurseries of recommended varieties and standard. Framers can himself produce planting materials after taking necessary training from the Directorate of Cashew research, Puttur.

(iv) Management of plant canopy architecture

Canopy management in cashew has direct impact on vigour of plants which eventually influencing yield and quality of nuts. Therefore, proper training should be done from the beginning in order to develop ideal frame work. Sprouts emerging from the rootstock are to be removed at regular intervals as and when seen. The graft should be allowed to grow by maintaining single stem up to 0.75 to 1 m height by removing sprouts or side shoots not only below the graft union (stock portion) but also above it. The flower panicles emerging later in the season need to be removed during the first two years of growth of the graft to facilitate proper vegetative growth and thereby achieving proper height and good canopy. The plants are to be allowed to flower and fruit from third year onwards. The well spaced branches (4-6) should be allowed in all directions. For better fruiting regular pruning is important based variety and vigour of plant.

(v) Rejuvenation of senile cashew orchards

In older cashew plantations, removal of dried or dead wood, criss-cross branches, water shoots etc. should be done at least once in 2-3 years. Redevelopment of canopy is possible by heading back of existing senile trees which have exhausted canopies and erratic growth resulting in reduced yield. Heading back if done at 1.0-1.5 m height of the trees new flushes will emerge from dormant buds on remaining trunk and develops into a vigorous new canopy. By and large old cashew plantations are of seedling origin and have become senile. Such trees can be rejuvenated by grafting with scion sticks of improved and high yielding varieties on new shoots arising on beheaded stumps. May-June is the right time for beheading and July-August is for grafting. However, preventative measures need to be taken to monitor each plant for the attack of cashew stem and root borer on the top worked trees.

(vi) High density planting

High density planting technique in cashew has provided higher yield and better economic returns per unit area in the initial years, but also helped more efficient use of inputs. Further, high density planting reduces the weed growth by early canopy coverage, reduces soil temperature thereby increasing the soil moisture content especially during peak summer season and provides mulching effect. In high density planting, closer spacing [6.5 m × 4 m (384 plant density/ha), 5 m × 5 m (400 plant density/ha) and 5 m × 4m (500 plant density /ha)] has given two times more yield than normal spacing. Cashew nut yield can be increased to four folds up to 6 years and 2.27 folds up to 12 years in high density planting system. High density planting system however needs suitable dwarf and / or compact cashew varieties so that overlapping of canopy is kept at minimum. High density planting with dwarf and compact canopy varieties shall be the best breeding strategy for increasing productivity of cashew per unit area. Limb pruning and diagonal thinning can also be evaluated for their effectiveness in high density planting systems.

(vii) Soil and water conservation techniques

Cashew is generally grown on degraded lands and experiences severe moisture stress from January to May, which adversely affects flowering and fruit set. In order to harvest the rainwater and to make it available to the cashew plant during critical period, *in situ* soil and water conservation techniques are very important. Studies conducted at DCR, Puttur have indicated that coconut husks buried in trenches of 1 m width 0.5 m depth and 3.5 m length per plant opened across the slope between two rows of cashew helps in better soil and water conservation. Generally three to four layers of coconut husks are buried one above the other. The first layer is laid with the convex surface of the husk touching the ground. After spreading a layer of soil on the husks, the second layer of husks is laid in the same position. The last layer should be covered with soil upto 10 cm thickness. About 100 coconut husks are needed to bury in a trench of 3.5 m length. The coconut husk buried will enhance moisture retention of soil and make the same available to the plants during flowering and fruiting, thereby reducing fruit drop. Soil moisture content was considerably higher in soil and water conservation plots as compared to control plots (without soil and water conservation measures). With proper soil and water conservation, the soil loss can be minimized;

the runoff water from post-monsoon and pre-monsoon rainfall can be harvested and made available to the plant during the critical period.

(viii) Nutrient management

In India, cashew is mainly grown on laterite, red and coastal sands. It is also grown on black soils in Tamil Nadu and Andhra Pradesh to a limited extent. Though it is grown in almost all types of soils, it performs better in well drained, brown forest soils, red sandy loam and light coastal soil with a high water holding capacity and rich in organic matter. A large portion of cashew growing soils is reported to be acidic. Some of the major constraints to cashew production on acid soils are: Low soil pH brings associated problems, including Al, and Mn toxicity, low base saturation percentage, low available P and high P fixation capacity, low concentrations of exchangeable Ca, Mg, and K, reduced Zn, Mo and B availability and low microbial activity (nitrification), sensitivity to erosion, low water holding capacity, low permeability to air, water, and roots, slow water infiltration rate *etc.*

The major nutrient requirement of cashew plant demands more liberal application of N followed by K, while P is needed in comparatively lesser quantity. Nitrogen and P are most important nutrients during the pre-bearing stage, but at the bearing stage, K together with N is also important. Studies conducted at DCR, Puttur indicated that application of 500 g N and 125 g each of P and K and 10 kg poultry manure per tree per year under normal density planting system (200 trees/ha) and 250 g N and 50 g each of P and K and 10 kg poultry manure per tree per year under high density planting system (625 trees/ha) is found superior in terms of higher nut yield for rainfed cashew. The recommended dose of fertilizers for cashew for major producing states is given in the Table 1. The recommended dose of fertilizers during first year after planting is 1/5th of the full dose, 2nd year after planting is 2/5th, 3rd year after planting is 3/5th, 4th year after planting is 4/5th and 5th year onwards is full dose. In order to enhance the efficiency, fertilizers should be applied in a circular trench of 10 cm depth at a distance of 0.5 m, 0.75 m and 1.5 m away from the centre of the trunk in the first, second and third year onwards, respectively and covered with soil. Foliar sprays of nutrients (urea 2 to 4%; DAP 1%; orthophosphoric acid; $ZnSO_4$ 4%; Cu 0.3 to 0.6%) at the emergence of the flush, panicle initiation and fruit set stages ensure better fruit set and also enhance nut yield in cashew.

Table 1. Recommended dose of Fertilizers to Cashew for different states

State	Nutrient dose for mature cashew plantations (5th year of planting) (g/tree/year)		
	N	P	K
Kerala	500 750	125 325	125 750
Karnataka	500 500	250 125	250 125
Tamil Nadu	500	200	300
Andhra Pradesh	500 1000	125 125	125 125
Maharashtra	1000	250	250
Odisha	500	250	250
West Bengal	1000	250	250

Water soluble fertilizers such as urea, DAP, and MOP were suggested for fertigation through drip once in a week from December to March. With fertigation, the quantity of nutrients (through fertilizers and organic manure) to be applied can be reduced to half the quantity of recommended nutrients. It has been reported that an increase of 100 per cent and 226 per cent in yield in treatment receiving half of recommended dose of NPK in inorganic form (Recommended dose: 500 g N, 125 g each of P_2O_5 and K_2O/tree/year) of nutrients through fertigation and balance half applied in organic form through castor cake as compared to the above dose applied through soil and irrigated separately and, absolute control (without manure and irrigation) respectively indicating better nutrient use efficiency.

Majority of the cashew growing farmers do not apply fertilizers / pesticides / fungicides due to which the productivity of cashew is moderate. Hence, there is very vast potential of bringing the areas like NEH region under organic farming to take advantage of great demand globally for organically produced cashew. Organic production of cashew offers immense potential. Cashew plantations produce huge cashew biomass which can be recycled for supply of nutrients. About 5.5 t of cashew leaf litter and cashew apple (Recyclable cashew biomass) available per ha can be converted into 3.5 t of compost or vermicompost which contributes 50 per cent of the total nutrient requirement of cashew. Growing green manure crops such as glyricidia, sesbania, sunhemp and cover crops between two rows of cashew resulted in considerable improvement in soil moisture content and soil quality. The dry matter production of green biomass was about 7.65, 5.75 2.25 and 1.63 t/ha/year from *glyricidia*, sesbania, sunhemp and cover crop, respectively. The nutrient addition to soil was about 186 kg N, 23.6 kg P and 126.2 kg K and 141 kg N, 17.9 kg P and 162.3 kg K /ha through *glyricidia* and sesbania, respectively.

(ix) Water management

Generally, Cashew is grown as a rainfed crop, but the yield can be doubled if irrigated. The largest area under cashew cultivation is along the steep hillocks of West Coast region of India where the mean annual rainfall ranges from 3000 to 3500 mm with 80% of its contribution during June to September. Due to the non-uniform distribution of rainfall, cashew experiences severe moisture stress from January to May which adversely affects its flowering and fruit set, resulting in immature nut drop and lower productivity of cashew gardens. During fruiting season of cashew (February to May), a mean rainfall of around 67 to 415 mm is received. The water deficit is highest during March to May (112 to 183 mm). Cashew yields can be enhanced by providing protective irrigation with 200 L of water per tree once in 15 days from January to March during the summer season. Irrigation can be started after the commencement of flowering for better nut set, filling and yield. It has been reported that fertigation saved 50% in the fertilizer requirement and doubled the cashew yield.

(x) Cashew based cropping systems

During the initial age (upto first 3-5 yrs), several intercrops can be taken up between two rows of cashew plants to get more returns as well as utilize the solar energy and soil resources efficiently. Pineapple can be grown as a intercrop between two rows of cashew for the first seven years. The spacing to be maintained for cashew is 8m x 8m

(156 trees/ha) or 7.5 m x 7.5 m (175 trees/ha) or 10 m x 5 m (200 trees/ha). Growing pineapple in trenches across the slope between two rows of cashew helped to conserve the soil moisture, which in turn increased the yield of cashew (main crop) by 1.5 times compared to cashew alone. Pineapple can be grown as a profitable intercrop under irrigated as well as rainfed conditions in west coast region. Other suitable intercrops are tapioca, turmeric, ginger, cucurbits, colocasia and elephant foot yam.

(xi) Pest management

A large number of insect and pests have been reported in cashew but tea mosquito bug and cashew stem and root borer are the major pests of cashew. The tea mosquito bug (TMB), *Helopeltis antonii* Sign. (Heteroptera : Miridae) is the most serious foliage and fruit pest of cashew in India. Integrated pest management involving resistance and adopting spraying of insecticide is a good package to manage TMB. Mid season variety like Bhaskara is able to escape from the severity of the pest to certain extent. As the TMB incidence coincides with critical period of flushing, flowering and fruit set, need based spray as given below has been recommended.

Flushing	-	Lambda cyhalothrin (0.003%)
Flowering	-	Carbaryl (0.1%) or lambda cyhalothrin (0.003%)
Fruiting	-	Carbaryl (0.1%)

Cashew Stem and Root Borer (*Plocaederus ferrugineus* L.) (Coleoptera: Cerambycidae) is another important pest infesting cashew in all parts of India. Integrated pest management involving phytosanitation measures is found very effective in managing CSRB. The trunk portion is to be examined at least once during fruiting season (February - May) for initial symptoms of cashew stem and root borer infestation and grubs should be removed by carefully chiseling out the bark taking care not to damage more than half of bark circumference. Swabbing the pest infested portion after removal of different stages of pest occurring internally and drenching the root zone with chlorophyriphos (0.2%) as post extraction prophylaxis (PEP). Dead trees and those beyond recovery should be uprooted and removed before and after monsoon as they serve as natural inoculum repositories for further spread of this pest. The newly planted grafts should be trained to have branching at a height of 0.75 to 1.00 m from ground level for better inspection and management operations.

(xii) Harvesting of nuts and apples

Bearing commences after the third year of planting and the trees will be in full production by the tenth year whilst the economic life of a tree is about 20 years. The main harvesting season is from February to May. Most farmers harvest their crop before they drop to prevent pilferage. This very often results in poor quality of the kernels. The optimum stage of harvest is when nuts drop to the ground. High quality nuts are obtained when freshly fallen nuts are separated from the cashew apples and sun dried for 2-3 days to bring down the moisture percentage from about 25 per cent to below 9 per cent. It is very essential to dry the nuts in order to prevent spoilage during storage. The drying process helps to retain flavor and quality of the kernels. When cashew apples are used for processing, harvesting has to be carried out before they drop. A simple test of maturity is to float nuts in water when mature nuts will sink

while the immature and unfilled nuts will float. Nuts are usually gathered every week during the harvest season. Ripe cashew apples for the fresh fruit should be harvested daily before they drop of on ground.

MAJOR ISSUES AND CHALLENGES

Researchable issues

Genetic Resource Management:

i) Narrow genetic base.
ii) Introduction of germplasm with desired traits.
iii) Cryo-preservation of germplasm.

Crop Improvement:

i) Development of dwarf genotypes with high yield potential suitable for high density planting.
ii) Varieties for cold tolerance, variable CNSL content, cashew apple, early maturing varieties. for NEH region and nutrient efficient varieties with synchronized flowering and fruiting.
iii) Development of SSR markers.
iv) Linkage mapping to identify markers linked to economic traits.
v) Introgression of genes from wild species.

Crop Management:

i) GIS based delineation of cashew area.
ii) Variety and location specific management.
iii) Development of nutrient diagnostic norms.
iv) Input use efficiency.
v) Foliar feeding and use of growth regulators.
vi) Management of canopy architecture.
vii) Identification of rootstock.
viii) Cashew based cropping systems.
ix) Better understanding of crop phenology.
x) Farm mechanization.

Crop Protection:

i) Development of pheromone and kairomone traps.
ii) Utilization of entomopathogenic nematode (EPN) for management of cashew stem and root borers (CSRB) and fungal pathogens for tea mosquito bug (TMB).
iii) Development of pest forecasting models.
iv) Evaluation of new and safer molecules for management of pests.
v) Economic threshold level for foliage pests.
vi) Monitoring pests and disease dynamics in the scenario of climate change.

Post – Harvest Technology:

i) Efficient mechanization of cashew processing.
ii) Development of standards for raw cashewnuts.
iii) By-product utilization.
iv) Product diversification.
v) Non-thermal processing of cashew (cold).

Transfer of Technology and HRD:

i) Constraint analysis in technology adoption.
ii) ICT based TOT.
iii) Crop advisory system.
iv) Human Resource Development.

Policy Issues:

i) Poor coordination between research and development agencies.
ii) Reliable data base.
iii) Crop insurance.
iv) Minimum support price.

CHALLENGES

Genetic Resources:

i) *In vitro* clonal regeneration.

Crop Improvement:

i) Development of varieties resistant to CSRB and TMB.
ii) Breaking the yield barrier.

Crop Management:

i) Enhancement of cashew productivity.
ii) Expansion of area under moderate cold climate.
iii) Organic production of cashew.
iv) Sustained supply of raw cashew nuts to industries.

Crop Protection:

i) Eco-friendly and cost effective management of CSRB and TMB.
ii) Early detection of CSRB infestation.

Post-Harvest Technology:

i) Automation of cashew processing.
ii) Commercialization of cashew apple based value products.

SOFTWOOD GRAFTING TECHNIQUE AND NURSERY MANAGEMENT IN CASHEW

MG Nayak
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1. INTRODUCTION

Cashew is a cross pollinated and therefore, the seedling progenies are heterogenous due to segregation. Whereas the clonal progenies are true-to-true of the mother plant and give relatively more uniform yield and come to fruiting earlier than the seedling progenies. Different methods of vegetative propagation, namely layering, grafting and budding have been tried in cashew both at National Research Centre for Cashew (NRCC) and different Cashew Research Stations in the country. Studies conducted at NRC Cashew, Puttur and All India Coordinated Research Project (AICRP) on Cashew Centres, have indicated the superiority of “Softwood grafting” technique over other methods and hence, this technique has been standardized and recommended for taking up of commercial multiplication of cashew varieties.

In case of softwood grafting about two month old root stocks of cashew and 3-5 month old scions are utilized for grafting by adopting “cleft or wedge” method of grafting. Since softwood portion of the rootstock is utilized for making cleft and the scion is mended into wedge shape, this method is know as softwood grafting technique.

Softwood grafts can be prepared almost throughout the year with a mean graft success of 65-70 per cent saleable grafts. However, the best season for grafting would be June to November under Dakshina Kannada weather conditions. The cost of production is comparatively cheaper and field establishment of softwood grafts is very high.

2. TERMINOLOGIES

Grafting	:	Grafting is joining of two plant parts.
Root stock	:	Rootstock is the lower portion of the graft which has the root system of the grafted plant
Scion	:	Dormant buds is a short piece of detached shoot (lateral shoot) containing several dormant buds, which when united with root stock results in the upper portion (canopy) of the grafted plant.
Wood / sap wood (xylem)	:	Through wood the sap is drawn up from the roots and translocated to leaves.

Bark (phloem)	:	The carbohydrates synthesized in the leaves will be distributed / transported to roots via phloem. Protecting the phloem there is an outer skin called the bark.
Cambium layer	:	It is one celled thick strip around the outer side of sap wood (xylem) and inner side of bark (phloem). It manufactures new growth by rapid multiplication of cells. Cambium layer is important in healing of graft joint and establishing the connection between root stock and scion.

3. SCIONS FOR GRAFTING

a) Production of scion sticks

Scion bank for the recommended cashew varieties should be established by adopting a closer spacing of 4m x 4m and it should be maintained properly for getting continuous supply of scion sticks for commercial multiplication.

b) Selection of scion sticks and precuring

- Non flowered lateral shoots of current season's growth (3-5 month old) are to be selected.
- The selected shoots should be 10-12 cm long, straight, uniform round with brown coloration and of pencil thickness.
- The leaves are to be removed using a secateur (precuring or defoliation) 10 days in advance of grafting.

c) Collection of scion sticks

- The precured scion sticks should be collected from the mother trees before the terminal buds sprout.
- The scion sticks should be separated from the mother tree preferably during morning hours.
- The detached scion sticks may be dipped in cold water and then placed in a polythene bag of 100 gauge thickness and brought to the grafting shed and utilized for grafting.

4. ROOT STOCK SEEDLINGS FOR GRAFTING

a) Selection of cashew seeds for sowing

- Cashew seeds should be collected during the peak period of harvest (February-April).
- Collected from a single variety block.
- The seeds should be sun dried for 2-3 days.
- Medium sized (6-7g) and dense seeds should be selected.
- The seeds gradually loose viability after 8-10 months of storage.

b) Preparation of potting mixture and filling of polythene bags

- The potting mixture should be prepared in the proportion of 1:1:1 (red soil; coarse river sand: compost) in heavy rainfall areas and 1:1 (red soil: Compost) in low rainfall areas. Rock Phosphate @ 5g/kg of potting mixture may also be added for getting good root growth of seedlings.
- Polythene bags of 25 cm x 15 cm size and 300 gauge thickness should be used for filling potting mixture.
- In heavy rainfall areas, 30-40 drainage holes of 0.5 cm diameter may be punched uniformly on the polythene bags. In low rainfall areas, the number of drainage holes can be few.
- Potting mixture should be filled upto the brim level.
- The filled bags should be arranged in beds of 1000 number each (100x10).

c) Sowing of seeds

- The cashew seeds should be soaked in water for 12-24 hours before sowing. Seeds need not be presoaked during rainy season.
- The seeds should be dibbled in the centre of the polythene bags, stalk-end upwards and covered with little soil.
- The depth of sowing should be not more than 2.5 cm.
- Immediately after sowing and every day after sowing the seed beds should be watered depending upon the weather conditions.

- During rainy days, if water stagnation is observed, excess water should be removed by pressing the sides of bags.
- During dry months seedbeds may be mulched with paddy straw till the germination takes place. Agro shade nets may also be used for this purpose.
- The seeds will germinate 10-15 days after sowing depending on the weather condition.
- Seeds should be sown at regular intervals (weekly/fortnightly) to get continuous supply of desired root stock seedlings for grafting depending upon the number of grafters available.

d) Maintenance of seedlings in the nursery

- The seedlings should be watered daily depending upon the weather conditions.
- During monsoon season, if water stagnation is observed, the polythene bags may be pressed from sides, so that the excess water drains out of the bags. This reduces the incidence of collar rot/damping off of seedlings.
- During rainy season, the seedlings should be sprayed with Bordeaux mixture (1%) at 10 days interval to control collar rot/damping off of seedlings.
- The seedlings may be sprayed with systemic insecticides such as monocrotophos (1.5 ml/litre) to control tea mosquito and other pests at regular intervals.
- The side shoots arising from the axils of leaves should be removed frequently in order to get vigorous seedlings with single main stem.

5. SOFTWOOD GRAFTING TECHNIQUE

a) Preparing the root stock seedling for grafting

- The grafting operation should be carried out under the shade either in a grafting shed or makeshift shelters.
- About two month old seedlings (of 25-30 cm height) are selected as root stocks. The girth of the seedling should be about 1cm at the place of grafting.
- On selected root stock seedling, two pairs of bottom leaves are retained and the other leaves are removed with a sharp grafting knife.

- Then the terminal shoot is decapitated at a height of 15 cm (where soft wood portion is available for grafting).
- A cleft of 6-7 cm deep is made on the decapitated stem.
- From the inner sides of the cleft a little portion of wood is removed at the tip.

b) Preparing the scion stick for grafting

- If the scion stick is longer, then it should be reduced to a length of 10-12 cm by cutting off the excess portion at the bottom. Very short scion sticks should be discarded.
- The scion stick should be carefully mended into a wedge shape of 6-7 cm long. However, care must be taken to retain the bark on either side of the wedge. The cut surface should be smooth and it should not be soiled at the time of preparing the wedge.

c) Grafting operation

- The wedge of the scion is inserted carefully into the cleft of the root stock. If the scion is thicker in girth, then care must be taken to match the cambial layers of both root stock and scion at least on one side with the help of finger.
- Then the graft joint is secured firmly with a polythene strip (2.0 cm wide, 30 cm long and 100 gauge thickness).
- Then a long and narrow white polythene cap (20 cm x 4 cm size and 200 gauge thickness) is inserted on the grafted plant.
- After 3 weeks, the polythene caps are removed gently and the grafts are shifted to open area in the nursery.
- At the time of removing the caps, about 70-80 per cent of the grafts show sprouting.

6. SEASON OF GRAFTING

Monsoon season (June-November) is the best season for grafting under the weather conditions of Dakshina Kannada (West Coast) and a graft success of over 80 per cent can be obtained due to favourable weather conditions and availability of proper mature scion sticks. During other season the graft success varies from 50-60 per cent due to non availability of proper mature scion sticks in sufficient numbers and less favourable weather conditions. However, soft wood grafts can be produced

almost throughout the year with a mean graft success of 65-70 per cent. Grafting may be suspended during Dec-Jan as there will be poor graft success in winter.

7. MANAGEMENT OF GRAFTS IN THE NUSERY

Generally the cashew grafts produced during monsoon season (June- November) are to be maintained in the nursery till the next planting season (July-August). Therefore, the following points should be considered:

- In the nursery, the grafts should be arranged in beds after spreading black polythene sheet on the ground to prevent the grafts from striking their roots into the ground. Otherwise, frequent shifting of grafts from one place to another place is required which involves labour.
- The grafts should be watered daily depending upon the weather conditions.
- During heavy rainy season, if water stagnation is observed in the bags, then the excess water may be removed by pressing the sides of the bags.
- During summer, the grafts should be provided with partial shade by erecting pandal and covering with agro shade nets (35-50% shading). As soon as the monsoon starts, the shade should be removed. Complete shading should be avoided as it results in lanky and weak growth of grafts. Laminated shade nets (35% shading) may also be used.
- During rainy season, the grafts may be sprayed with bordeaux mixture (1%) at 10-15 days interval. Spraying should be done when the weather is clear.
- The grafts may be sprayed with systemic insecticides such as monocrotophos (1.5 ml/litre) to control insect pests such as tea mosquito, leaf minor, leaf eating caterpillars etc.
- The side shoots arising from root stock portion of the grafts should be removed frequently.
- During November/December, the flower panicles coming from the grafts in the nursery should be removed frequently.
- After 4-5 months of grafting, the polythene strip should be removed from the graft joint. Otherwise, there will be girdling at the graft joint. However, the polythene strip should be removed before selling the grafts.
- After three-four months of grafting, the bottom leaves on the root stock portion of the graft should be removed.

8. COST OF GRAFT PRODUCTION

On an average 65-70 per cent saleable grafts can be realised on commercial scale. The estimated cost of production per graft varies from Rs.13/- to Rs.14/- depending upon the cost of inputs (cost of materials and labour).

9. GRAFT PRODUCTION UNDER LOW COST POLYHOUSES

By employing low cost polyhouses, softwood grafts can be produced almost throughout the year. Low cost polyhouses prepared from casuarina poles/areaca reapers etc. and covered with Silpaulin brand plastic film (natural colour) of convenient dimensions (preferably 11 m long and 6 m wide sheets with eyelets at regular distance) may be utilized for grafts production. The height of polyhouse in the centre should be 2.0-2.25 m and the height in the sides should be 1.0 m. Depending upon the cost of material (Silpaulin sheet, poles, GI wire etc.) and labour, each polyhouse may cost about Rs. 3000/-. Each polyhouse may accommodate about 4000 filled bags of 25 cm x 15 cm size and about 6000 filled bags of 20 cm x 12.5 cm size. Raising of rootstock seedlings, grafting of rootstocks and further maintenance of grafts can be done inside the polyhouses. This will save the labour required for supplying root stock seedlings from nursery area to grafting shed and shifting of grafts from grafting shed to nursery area. The polyhouses will also give protection to the seedlings and grafts during heavy rainy season and reduce the mortality due to fungal diseases. The plants may be watered using hose pipe fitted with a fine rose. Misting units may also be fitted at suitable points and switched on for about 5-10 min at an interval of 2 hours from 10 AM to 6 PM during summer months. This reduces the temperature build up inside the polyhouses. During summer months the Silpaulin sheet has to be removed and shade net (35-50% shade) is to be used.

10. GENERATION OF CASHEW PLANTING MATERIAL

Government of India, realizing the viability of the softwood grafting technology, has come forward during the VIII Five year plan to establish Regional Nurseries in different cashew growing States. Today we have 83 units of Regional Nurseries in the country supported by Directorate of Cashewnut and Cocoa Development (DCCD), Ministry of Agriculture, Cochin. These nurseries have the production potential of over 80 lakh grafts annually. From 1992-93 to 2000-2001, these Regional Nurseries could produce and supply about 3.77 crores of quality planting material to the farmers and development agencies, covering an area of about 1.70 lakh ha. With the area expansion taking place with high yielding clones, we will be able to achieve the requirement of one million tons of rawnuts for processing in India.

11. IMPORTANT DO'S AND DONT'S

- The length of scion should be 10-12 cm with pencil thickness.
- Very short scions and very thin scions should not be collected for grafting.
- For raising uniform and vigorous root stocks, always collect seeds from a single variety block and use graded seeds (mediums size and dense seeds).
- Application of good quality compost / cattle manure is a must to raise healthy and vigorous seedlings with proper stem girth.
- Pre-soaking of seeds for 12-24 hours helps in quicker and good germination.
- Seeds should be sown at weekly/fortnightly intervals to get continuous supply of desired root stock seedlings.
- To control the collar rot incidence in the germinating seeds and young seedlings of less than one month old, spraying of Bordeaux mixture (1%) during rainy season at 10-15 days interval is to be done.
- At the time of grafting two pairs of bottom leaves should be retained on the root stock and a cleft of 6-7 cm deep is to be made at a height of 15-20 cm.
- The scion should be mended into a wedge shape of 6-7 cm length.
- The cut surfaces of the wedge should be smooth and they should not be soiled or disturbed by touching with fingers.
- At the time of grafting, the cambial layers of both rootstock and scion should be aligned atleast on one side with the help of finger.
- The graft joint should be secured firmly with a polythene strip of 2.0 cm width and 30 cm length and 100 gauge thickness. Thicker gauge strips should not be used, as this results in loose tying and failure of graft joint to heal. Moisture may also enter through the graft joint resulting in rotting at graft joint.
- The grafted plants should not be allowed to strike their roots into the ground. In order to overcome this problem, arrange the grafts on black polythene sheet (300 gauge thickness) in the nursery.
- During summer months the grafts should be provided with partial shade (< 50% shade) using agro shade nets / coconut fronds. Complete shading should be avoided. Shade nets should be removed when once the monsoon sets in.
- The suckers arising from rootstock portion of the graft, and flower panicles arising from scion should be removed.
- The polythene strip from the graft joint should be removed after five months of grafting, before girdling takes place at the graft joint.

- Before sale, the grafts in the nursery are to be hardened by withholding water or watering on alternate days.

- Low cost polyhouses may also be used for graft production. Raising of root stock seedlings, grafting and maintenance of grafts etc. can be done inside the polyhouses. This will save labour required for shifting of plants. The polyhouses will also give protection from rains and incidence of collar rot will be minimum.

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SPECTRUM OF VARIABILITY IN CASHEW: CONSERVATION AND UTILIZATION

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Introduction:

Cashew (*Anacardium occidentale* L.) belongs to the family *Anacardiaceae* and is a native of Brazil. It was introduced to India by Portugese during 16th century. Presently, the cashew plants in wild state as well as in well managed orchards are seen in Maharashtra, Goa, Karnataka and Kerala along the west coast, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal on the east coast. To a limited extent, the crop is also seen growing in Chattisgarh, Gujarath, Assam, Arunachal Pradesh, Meghalaya, Tripura, Manipura, Nagaland and Andaman and Nicobar Islands (Singh 1998). After the establishment of National Research Centre for Cashew (NRCC) at Puttur, Karnataka in 1986 (Now the Directorate of Cashew Research-DCR), the germplasm collection through vegetatively propagated material started and since then, a coordinated approach was brought in the cashew gemplasm collection by organizing joint survey teams consisting of scientists of DCR and the centres of All India Coordinated Research Project on Cashew (AICRP on Cashew) of the respective cashew growing states (Bhaskara Rao and Swamy, 2000).

The germplasm survey and collection were carried out in cashew growing States namely Karnataka, Kerala, Maharashtra, Goa, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. The non-traditional areas such as Garo Hills (Meghalaya), Bastar (Chhattisgarh), Gujarath, Dadra & Nagar Haveli and Andaman & Nicobar Islands were also surveyed for germplasm collection. So far, 539 accessions have been collected and conserved in the National Cashew Field Gene Bank (NCFGB) at the Directorate. Similarly, Regional Cashew Gene Banks (RCGBs) have been established at AICRP Centres which are maintaining a total of 1370 accessions (Table 1).

Evaluation and characterization of cashew germplasm

For systematic characterisation of cashew germplasm, the collected scion material of the accession is grafted onto a suitable root stock and each grafted accession is then grown in the field gene bank with 6 grafts/accession and spacing of 6m x 6m at the Directorate. Recommended agronomic practices are adopted and observations are recorded on 3 selected plants in each accession after 10th year of planting and after obtaining 6 annual harvests for 68 descriptors following “Cashew Descriptors” (IBPGR 1986). So far 478 clonal accessions out of 539 accessions have been evaluated and 444 are conserved in a conservation block by planting 4 plants per accession at a closer spacing of 4 m x 4m.

The information on first set of 56 accessions planted in 1986 was published in the Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-I during 1997. The second set of 97 accessions planted in 1987 and 1988 was documented in the Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-II during 1998. The third set of 102 accessions planted in 1989 and 1990 has been included in the Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-III during 2000. These are the first efforts made in characterisation of clonal accessions of cashew in the world and so far, 255 accessions have been characterised and catalogued (Swamy et. al 1997, 1999 and 2000). Recently, fourth catalogue containing information on 108 accessions planted during 1991-97 and fifth

catalogue containing information on 115 accessions planted during 1998-2003 have been prepared and are in process of publication. An attempt has been made to develop a core collection of cashew germplasm from 255 accessions of cashew and these accessions were grouped into 22 clusters following K-clustering analysis and from each group a 10 per cent sample size was randomly selected as core entries.

The germplasm accessions which are unique and have potential (verified / verifiable) attributes of scientific/commercial value are registered in NBPGR, New Delhi (Table 2)

Unique types in germplasm accessions

The germplasm accessions conserved in the NCFGB at DCR, Puttur include the diverse types such as high yield, bold nut, semi-tall, compact, Cashew Nut Shell Liquid (CNSL) free, purple pigmented, high shelling percentage, cluster bearing, big apple and early maturity types. The range and mean of characters for some quantitative characters is given in the Table 3. Three wild species namely, *Anacardium pumilum, A. othonianum* and *A. microcarpum* are also conserved. The collection also has seedling accessions of 23 exotic collections of which nine were collected from Brazil, Nairobi, Mtwara, Lindi, Nacala, Mozambique, Ex Tanganyka, Singapore and Australia and 14 from Republic of Panama.

Utilisation of germplasm

Of the 29 cashew varieties and 13 hybrids released in the country, the varieties are *per se* selections made from the germplasm material. These 29 varieties were identified and released based on the germplasm evaluation carried out at different centres. About 155 germplasm accessions have been effectively utilized for crossing programme at the Directorate of Cashew Reserach (DCR), Puttur and several of these were also supplied to other cashew research centres for hybridization programme and other studies. For instance, a total of 75 cashew accessions have been supplied to AICRP on Cashew Centers/ICAR Research Complex for Goa for evaluation and hybridization programme. A total of 107 accessions (65 during 2001 and 42 during 2002 fruiting season) in NCFGB have been utilized as parents under the ad-hoc research scheme “Network Programme on Hybridization in Cashew” which was in operation during 2000-2003. Leaf samples of 34 varieties and 153 gemrplasm accessions have been supplied to Division of Horticulture, UAS, Bangalore for DNA Finger Printing of varieties and germplasm under the DST funded project. Leaf samples of 142 accessions have also been supplied to NRC DNA Finger Printing, New Delhi.

Presently, the hybridization programme is going on at DCR, Puttur and cashew research stations at Bapatla, Bhubaneswar, Vridhachalam, Madakkatahra and Vengurle. The review of performance of varieties and hybrids indicated that in the states where both selections and hybrids are released for cultivation, the performance of hybrids have been better than the selections. Hybrid vigour can easily be exploited in cashew because of the amenability of this crop for vegetative propagation. Recently, a program for development of varieties for cashew apple has been initiated at the Directorate with 14 selected accessions and this is expected to provide impetus for cashew apple utilisation.

Future Thrust Areas

Since there is a moderate amount of diversity available in Indian cashew germplasm due to limited introduction episodes, it is essential to introduce and enhance genetic variability from countries of Central and South America. The introduction of dwarf accessions from Brazil needs and subsequent development of dwarf hybrids needs special mention since dwarf types are very much required for high density planting systems to improve productivity. Generation of core collections, utilization of germplasm accessions in hybridization programs, exploitation of unique types such CNSL free and rich types are some of the areas that need attention in the ensuing days.

Table 1: Status of cashew germplasm holding in India

Centre	Number of accessions
DCR, Puttur (Nodal center)	539
East Coast	
Bapatla	132
Bhubaneshwar	104
Jhargram	150
Vridhachalam	208
West Coast	
Goa	89
Madakkathara	140
Paria	--
Pilicode	43
Vengurla	306
Plains tract/others	
Darisai	--
Hogalagere	128
Kanabargi	--
Jagdalpur	70
Tura	--
Total	1909

Table 2: Germplasm accessions from DCR registered with NBPGR, New Delhi

Accession	Traits of importance
NRC-59 (VTH 196/18)	Big apple, bold nut size and high shelling percentage,
NRC-111 (Mardol-4)	Mid season flowering, big apple and big nut size
NRC-116	Cashew Nut Shell Liquid (CNSL) free type
NRC-120 (Nairobi)	Early season flowering, bold apple and nut size
NRC-121 (Purple genotype)	Purple stem and leaves and high shelling percentage
NRC-140 (VTH 155 L)	Semi-tall, early season (Nov-Dec) and long flowering duration (120 days)
NRC 142 (VTH 578/1)	Wild relative with unique gene combination
NRC-152 (VTH 713/4)	Wild relative with unique gene combination
NRC-201 (Pl.No.1254)	Upright and compact habit, semi-tall type

Table 3: Range and mean of different characters in 478 germplasm accessions

Character	Range	Minimum	Maximum	Mean
Tree Height (m)	8.20	1.50	9.70	5.01
Tree Spread (m)	9.60	1.50	11.10	6.20
Nut Weight (g)	14.78	2.00	16.78	6.88
Sex Ratio	0.29	0.01	0.30	0.09
Apple Weight (g)	170.00	10.00	180.00	61.82
Shell Thickness (mm)	3.20	1.50	4.70	3.06
Flowering Duration (days)	88.00	42.00	130.00	82.54
Apple to Nut ratio	26.10	2.00	28.10	9.32
Shelling Percentage	27.30	15.30	42.60	28.50
Kernel Weight (g)	4.00	0.40	4.40	1.94
Leaf Area (sq.m)	131.30	37.00	168.30	87.33
Cumulative Yield per plant (kg)	27.24	0.29	27.53	10.49
Flowering Intensity (%)	82.50	14.30	96.80	65.78

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CASHEW VARIETIES FOR HIGHER PRODUCTIVITY

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The botanical name of cultivated cashew is *Anacardium occidentale* and it belongs to the family Anacardiaceae which also includes other tree crops like mango and pistachio. Cashew is a fast growing; ever green perennial tree well suited to the wet/dry tropical climate. The tree has a long productive life, perhaps up to 50 years, however in poor conditions the economic life of tree would be reduced. The cashew produces a nut containing a kernel, and also a fruit known as the cashew apple. The nut is processed for the kernel, which is sold as an edible nut and is the main economic product. The cashew apple has various uses; it can be eaten as fresh fruit, or processed into juice and other products. In Goa it is being exploited commercially for production cashew liquor called 'Feni'. There is also a by-product from processing the nut that is called cashew nutshell liquid (CNSL) which can be extracted from the spent shells of the nut during processing, and this product has various industrial uses.

The cashew tree originated in NE Brazil, and its cultivation has now spread to many tropical countries. Top five cashew producing countries are Vietnam, Nigeria, India, Côte d'Ivoire and Brazil (FAOSTAT data, 2013).The major export markets for the kernel are USA, Europe, Canada, Japan and Australia. China has also emerging as a major market. In addition India has a growing domestic market. The world production of cashew has doubled in the past 25 years; however world demand has increased at the same rate so that kernel prices have remained relatively stable over this period.

The present production of cashew in India 7.28 lakh tonnes whereas the requirement is 13-14 lakh tonnes which means that there is deficit of 50% in domestic production which is met by import of raw nuts from other countries. The lower production is due to the low productivity of cashew (772 /ha).This kind of situation warrants adoption of scientific strategies for increasing the domestic production in the light of declining import from cashew producing countries due to various reasons. The productivity is low particularly in Karnataka, Goa, Tamil Nadu, Andhra Pradesh and Odisha. The main factors for low productivity in these states are the large plantations under seedling origin and poor management practices. Cultivation of high yielding varieties is the most important step in improving the productivity of cashew.

Cashew variety screening procedure

Cashew does not grow true to type from seed, and seedlings raised from seed or nuts vary in several characteristics including growth habit (tree size and canopy shape) and nut quality. All cashew seedlings should be planted in similar conditions and receive a consistent management, so as to isolate and measure the genetic characteristics. The selection process involves

- the monitoring of performance of the trees over a long enough period in order to obtain a good measure of the seedlings potential.
- making selections based on the important criteria (nut yield/tree, nut weight, kernel weight, shelling percentage, export grade, time of bearing, tree shape)

- cloning the selected seedling by grafting or budding to produce replicates of that variety. These replicate trees are then used as "sources of scions for the large scale production of the selected variety
- these varietal trees are then used for commercial plantings.

During making selections it is essential to have sufficient data in order to have reasonable certainty of a correct decision. While monitoring a trees performance up to maturity (10 + years) would give a perfect data on the trees' potential, this is not a practical option in the business world. **Therefore in the balance of time and certainty of result it is recommended that a minimum of 3 years of data from immature trees is required** While in good conditions the trees may commence yielding in the second year, it is advisable to disregard this early yield as conclusive data. Serious crop data collection should commence in year 3 and continue in years 4 and 5. At age 5 the grower should have sufficient data to make a selection with confidence, however he should continue to monitor the selected tree after year 5 just for additional confirmation of his selection.

The final objective is to plant large scale commercial areas with a relatively small number of the elite varieties. The screening process may begin with 100s or 1,000s of trees, but perhaps only about 10 % representing the very best should be used for commercial production. However it is important not to eliminate any of worthwhile trees from the plantings as it is always possible that they may have some characteristics that can be utilized in a future hybrid breeding program.

Development of high yielding cashew varieties

As a result of evaluation of germplasm collected and evaluation of the hybrid seedlings, a number of varieties were evolved and released from various cashew research centers. As cashew is vegetatively propagated through wedge grafting or soft wood grafting, the superiority of a hybrid or selection can be easily maintained and fixed. In all, 53 varieties have been released from different research centers and DCR (formerly NRCC). Among them 33 are selections and 20 are hybrids (Table 1). Some of salient features of these varieties are presented below.

Varieties released from Andhra Pradesh

The Andra Pradesh Horticultural University (Formerly Acharya NG Ranga Agricultural University) has released the following seven cashew varieties for cultivation in Andhra Pradesh based on trials conducted at Cashew Research Station, Bapatla.

BPP 1
This is a hybrid (H2/11) developed from the cross between Tree No.1 as female parent and Tree No.273 as male parent and was released in the year 1980. The average yield is 10 kg/tree. The percentage of perfect flowers is about 13 with a fruit set of eight fruits per panicle. Nuts are medium in size with a nut weight of 5g and the shelling percentage of 27.5. Kernel protein percentage is 19.8%. The apple is medium in size and yellow in colour with the juice content of 57%. Kernel grade is W 400. This hybrid is withdrawn from recommendation for cultivation.

BPP 2
This is also a hybrid (H2/12) with the same parentage as BPP 1, that is, T.No.1 x T.No.273. Released in 1980. The average yield is 11 kg/tree. The nuts are small with a nut weight of 4g and shelling percentage of 25.7. The percentage of bisexual flowers is 8 with the fruit set of 8 to 10/panicle. The protein content of kernels is 21.3%. Juice content in apple is 67%. Kernel grade is W 450. This hybrid is withdrawn from recommendation for cultivation.

BPP 3
This is a selection from the germplasm collected from Simhachalam in Vishakapatnam district of Andhra Pradesh (3/3 Simhachalam) and the variety was released in 1980. Bisexual flower percentage is 15%. The average yield recorded was 11 kg/tree. The nut weight is 4.8g with shelling percentage of 28.1. Protein content is 19.0%. The apple has juice content of 67%. Kernel grade is W 400. This selection is withdrawn from recommendation for cultivation.

BPP 4
This is the selection from germplasm accession of 9/8 Epurupalem and released in 1980. This variety has distinct light pink pigmentation in their youngest leaves. The bisexual flower percentage is about 8%. The average yield is 10.5kg/tree with a nut weight of 6g. Shelling percentage is poor (23%). Protein % of kernels is 18.1%. The apple colour is yellow and shape is conical. Kernel grade is W 400.

BPP 5
This is the selection from germplasm accession T.No.1. This variety was released in 1980. The bisexual flower percentage is 10%. The nut weight is 5.2g. The mean nut yield is 11kg/tree with shelling percentage of only 24. Protein percentage is also rather low (16.8%). Apple has juice content of 64%. Kernel grade is W 400. This selection is withdrawn from recommendation for cultivation.

BPP 6
This is also a selection from germplasm collection. Tree NO.56 was the source material for this variety released in 1980. The mean bisexual flower percentage is 8% and mean yield of nuts is about 10.5kg/tree. The nut weight is 5.2g and shelling percentage of this variety is also only 24. Protein percentage is 20.3%. Juice content of apple is very high (74%). Kernel grade is W 400.

BPP 8 (H 2/16)
It is a hybrid (H2/16) derived from the cross Tree No.1 x Tree No.39 and released in 1993 for general cultivation in Andhra Pradesh. It has been performing well in Orissa and West Bengal also. This variety is superior to all the other six varieties developed from Bapatla. The variety has mean yield of 14 kg/tree with better nut size (8.2g). Shelling percentage (29%) of this variety is also better than the rest of the varieties released from Bapatla so far. Kernel grade is W 210 (export grade).

Varieties released from Tamil Nadu

The Tamil Nadu Agricultural University released four varieties from its Regional Research Station, Vridhachalam.

VRI-1 (M 10/4)
This variety is a selection from germplasm collected from Vazhisodhanipalayam in South Arcot District of Tamil Nadu. It has a medium sized tree having setting of 5 to 7 fruits per panicle. It was released in the year 1981 and the mean yield is 7.2 kg/tree under Vridhachalam conditions. The nut size is small with 5g nut weight and shelling percentage of 28%. The kernel grade is W 320. This variety is withdrawn from recommendation for cultivation.

VRI-2 (M 44/3)
This is the only variety released at national level based on the multilocational trial conducted at six coordinating centres. This national variety is a selection from the germplasm (T. No. 1668) collected from Kattupalli village of Minjur block of Changelpattu district of Tamil Nadu and released in 1985. This variety is found to be "prepotent" - meaning that the variety is capable of giving good seedling progenies irrespective of male parents. This variety is found adaptable over wide range of soils and regions. The percentage of bisexual flowers is 10 with a setting of 5-8 fruits per panicle. The average yield is about 7.4 kg/tree. The nut size is small with 5.1g nut weight with shelling percentage of 28.3%. The kernel grade is W 320. The colour of the apple is pinkish yellow. This variety is withdrawn from recommendation for cultivation.

VRI-3 (M 26/2)
This is a selection from seedling progeny of a high yielding tree collected from a village Edayanchavadi in South Arcot District of Tamil Nadu and was released in 1991. It has 12.1% perfect flowers. The average yield of this variety is about 10 kg/tree, thus the increase over VRI-2 and VRI-1 being 35 to 39% respectively. The nut size is medium with 7.2g nut weight and shelling percentage of 29.1%. The kernel grade conforms to W 210 export grade. This variety is picking up fast among farmers of not only of Tamil Nadu but also of other states.

VRI-4
This variety was released in 2000. It is a selection from vazhisodanaipalayam, Cuddalore district. The special features of this variety are nut weight 6.63 g, kernel grade W 240, shelling out turn 28.5%, compact canopy and mid season flowering type.
VRI (Cw) 5.

It is a hybrid developed from the cross M 26/2 (VRI-3) x M 26/1. This was released in the year 2007. The canopy type is compact and branching habit is spreading. The average yield of this variety is about 13.2 kg/tree. The nut size is medium with 7.2g nut weight and shelling percentage of 30.5%. The kernel grade is W 210. The apple colour is pink with yellow tinge and the shape is round and the apple weight is ranging from 50.0 to 53.5 g. This is recommended for all the cashew growing districts of Tamil Nadu.

Varieties released from Orissa and West Bengal

In IX Biennial Workshop of AICRP on Cashew held in 1989 at Coimbatore, Bhubaneswar-1 for Orissa and Jhargram-1 for West Bengal were recommended for release.

Bhubaneswar-1
It is a selection from seedling progeny of WBDC V (Vengurla 36/3), a collection from Regional Fruit Research Station, Vengurla and released in 1989. Flowering season is from January to March with medium duration of 70 days. It has cluster bearing habit with about 12 fruits per bunch. This variety has average yield of 10 kg/tree with small nut size (4.6g nut weight). The shelling percentage is high (32%) with kernel grade of W 320. It has been found suitable for cultivation in the sandy and laterite soils of the East Coast.

Jagannath (BH 6)
It is a mid season flowering (Jan-Mar) variety having bold nuts with 8.6 g nut weight. The variety gives an average nut yield of 2.1 t/ha (10.5 kg/tree) and possesses high shelling percentage (32.5 %).

Balabhadra (BH 85)
It is an Early flowering (Dec-Feb) variety having bold nuts with 7.4 g nut weight. The variety gives an average nut yield of 2.0 t/ha (10.0 kg/tree) and possesses high shelling percentage (30.0 %).

Jhargram-1
It is a selection from T.No.16 originally collected from Bapatla. It was released in the year 1989. It has a medium compact canopy and intensive branching habit. It has on an average, 6 fruits per bunch and yield of 8.5 kg/tree with small nut size (5g nut weight). Shelling percentage is 30 and kernel grade is W 320.

Bidhan Jhargram-2
It is selection made from seedling plantation of H-2/15 of Regional Research Station, Bidan Chandra Krishi Viswa Vidyalaya, Jhargram, West Bengal. The variety has mid season flowering habit with 3-4 fruits per panicle. Apple is golden yellow with a weight of 63g and a mean juice content of 68.9 per cent. The average nut weight is 9.2g with a kernel weight of 2.85g and high shelling (32%). The kernel grade is W 180.The variety can yield 13.5 kg/tree in 7^{th} harvest.

Varieties released from Chhattisgarh

The AICRP- Cashew centre located at Jagadalpur, under Indira Gandhi Krishi Viswa Vidyalaya(IGKVV), Raipur has released Indira Kaju-1, a cold tolerant cashew variety, the characters of which are as follows.

Indira Kaju-1
It is a clonal selection from natural pollinated seedling. Nut weight is 10.50g. It has field tolerance to tea mosquito bug and cashew stem and root borer. Shelling percent is 28.65% and colour of mature nut is grey. Average yield is 15.53 kg/tree. Tolerant to low temperature and recommended for Bastar Plateau Zone, Jashpur and Raigarh (Zone VII of Indian Agroclimatic Zone).

Varieties released from Maharashtra

Based on the evaluation of selections from germplasm and hybrid progenies in varietal evaluation trials conducted at Regional Fruit Research Station, Vengurla, the Konkan Krishi Vidyapeeth (KKV), Dapoli has released the following seven varieties for cultivation in Maharashtra. These varieties have been found to perform well in Goa also. Vengurla-1 and Vengurla-4 are doing well in Uttar Kannada district of Karnataka also. Varieties such as Vengurla-1, Vengurla-4 and Vengurla-6 are in great demand from farmers. Vengurla-7 which has been released in 1997 is suitable to Konkan region of Maharashtra and also adjoining cashew growing regions of Goa and Karnataka.

Vengurla-1
This is a selection from the germplasm (Ansur-1) collected from Ansur village in Vengurla Tehsil of Maharashtra. This was released in the year 1974. The average percentage of perfect flowers is about 8%. The average yield is 19 kg/tree. The nut weight is 6.2g with the shelling percentage of 31. It is early flowering variety. Colour of the apple is yellow. Kernel grade is W 240.

Vengurla-2
This variety was released in the year 1979. It is a selection from germplasm collected from West Bengal (WBDC VI : Vengurla 37/3). This selection has average perfect flower percentage of 8% and also has short flowering and fruiting phase. The average yield is about 24 kg/tree (in 20th year of age). But the nuts are small with 4.3g nut weight and shelling percentage of 32. Colour of apple is pinkish red. Kernel grade is W 320. This variety is withdrawn from recommendation for cultivation.

Vengurla-3
This is a hybrid developed from the cross Ansur-1 x Vetore 56 and was released in 1981. The percentage of perfect flowers is 25% with an average fruit set of 7%. Average yield is 14.4 kg/tree. This is a bold nut variety with the nut weight of 9.1g and shelling percentage of 27. Kernel grade is W210 (export grade). This hybrid is withdrawn from recommendation for cultivation.

Vengurla-4
This is a hybrid variety with the parentage of Midnapore Red x Vetore 56 and was also released in 1981. It is a cluster bearing type and with percentage of perfect flowers of 35 and fruit set of 6%. The yield of nuts is 17.2 kg/tree. The nut weight is 7.7g and shelling percentage is 31. The colour of the apple is red. Kernel grade is 210 (export grade).

Vengurla-5
This variety is a hybrid having the parentage of Ansur Early x Mysore Kotekar 1/61. This variety was released in 1984. Very high perfect flower percentage of 50.5% was recorded in this variety. But the fruit set is only around 3.3%. The average yield is 16.6 kg/tree. The nut size is small with 4.5 g nut weight. The shelling percentage is 30. This variety produces small golden yellow coloured apples. Kernel grade is W 400. This variety is withdrawn from recommendation for cultivation.

Vengurla-6
It is a hybrid of cross combination Vetore 56 x Ansur - 1 and released in the year 1991. The variety has average yield of 13.8 kg/tree with nut weight of 8g. The kernel grade is W 210. This variety is popular among farmers.

Vengurla-7
Hybrid 255 evolved at Regional Fruit Research Station, Vengurla under Konkan Krishi Vidyapeeth, Dapoli was recommended for release under the name "Vengurla-7" in the XIII Biennial Workshop of AICRP on Cashew held in November 1997. Vengurla-7 is a hybrid developed from the cross Vengurla-3 x M 10/4 (VRI-1). The percentage of perfect flowers is very high (40%). Average yield is 18.5 kg/tree. It is a bold nut type with nut weight of 10g and shelling percentage of 30.5. Kernel grade is W 180. The colour of apple is yellow with apple weight of 60g and with juice content of 75 per cent. Average weight of kernel is 2.9g. This variety is recommended for the Konkan region of Maharashtra and adjoining cashew growing regions of Goa and Karnataka.

Vengurla-8
It is a hybrid released in 2001 and yields 15-20 kg /tree. It has bold nuts with 86 nuts / kg. it is red apple variety with juice recovery is 85%.

Varieties released from Goa

Total of 2 cashew varieties were released from Goa state. Goa-1 was recommended for release in the XIV Biennial Workshop of AICRP on Cashew held at Bhubaneswar in October 1999. Thus this is the first time farmers of Goa are having opportunity to grow a cashew variety developed in their own state. Goa-2 was recommended for release in the National Group Meeting of Scientists of AICRP-Cashew held in Goa in November 2007.

Goa-1 (Balli-2)
Goa-1 was developed and released from ICAR Research Complex, Goa in 1999. It is the first cashew variety released from the state of Goa. It is a selection from accession Balli-2 which is originated from a tree located in Balli village of Quepem taluk of Goa. The average yield of Goa-1 is 7.0 kg/tree with nut weight of 7.6 g (range : 7.3 - 7.9 g) and the shelling percentage of 30.0 (range : 28.9 - 31.0%). Kernel weight is 2.2 g. The kernel grade is W 210. Apple colour is yellow and with average weight of 66.7 g and with average juice content of 68.0%. It is recommended to the state of Goa.

Goa-2 (Tiswadi-3)
Goa-2 was developed and released from ICAR Research Complex, Goa in 2007. It is a selection from Ela village of Tiswadi taluk of North Goa District. The average yield of Goa-2 is 5.5 kg/tree with nut weight of 9.4 g (range : 9.2 – 9.6 g) and the shelling percentage of 29.25. Kernel weight is 2.3 g. The kernel grade is W 210. Apple colour is yellowish orange with cylindrical shape and with average weight of 105 g. Juice content ranges from 68.0 – 72.0 per cent. It is recommended to the state of Goa.

Varieties released from Kerala

Kerala Agricultural University released eight varieties so far under AICRP-cashew programme. BLA 139-1 was released as Anakkayam-1 in 1985 for cultivation in Kerala. In 1987, three selections (BLA 39-4, NDR 2-1 and K-22-1) were released. In 1993 two hybrids (Kanaka and Dhana) and in 1995 one hybrid (Priyanka) were released. In 1999 one more hybrid (Amrutha) was released.

Varieties released by Cashew Research Station, Madakkathara

BLA 39-4 (Madakkathara-1)
It is a selection from seedling progeny of Tree No. 39 of Bapatla. The variety was released in 1987. The flowering season is from November to January. The mean yield is 13.8 kg/tree. The nuts are medium sized with 6.2g nut weight. Shelling percentage is 26.8. The kernel weight is 1.6g and kernel quality conforms to W 280. Apple colour is yellow with a weight of 52g. Reducing sugar content is 10.5%.

NDR 2-1 (Madakkathara-2)
This is a selection from germplasm collection made from Neduvellur in Kerala maintained at CRS, Anakkayam. This variety was also released in 1987. The mean yield is 17 kg/tree. The nuts are bold (7.3 g nut weight) with shelling percentage of 26.2%. Kernel weight is 2g having a count of W 240 export grade. Apple colour is red and with weight of apple 63.3g. Reducing sugar content is 7.8%.

K-22-1
It is a selection from clonal progeny of Kottarakkara-22 (Layer 23) maintained at CRS, Kottarakkara and was released in 1987. This variety has a mean yield of 13.2 kg/tree. The nut weight is 6.2g and the shelling percentage is 26.5. The kernel weight is 1.6g with kernel count of W 280. The apple colour is red and weight of apple is 74g. Reducing sugar is 7.2%.

Kanaka (H 1598)
It is a hybrid of cross BLA 139-1 X H 3 - 13 released in 1993 from CRS, Madakkathara. It is an early variety. Average yield is 19 kg/tree with a mean nut weight of 6.8g. Shelling percentage is 31%. Kernel weight is 2.1g and quality of kernels conform to W 210 export grade. Colour of apple is yellow.

Dhana (H 1608)
It is a hybrid of cross ALGD-1 X K 30-1 released from CRS, Madakkathara in 1993. It has cluster bearing habit. The mean yield is 17.5 kg/tree with a shelling percentage of 28. Kernel weight is 2.2g conforming to export grade of W 210. Yellow is the apple colour.

Priyanka (H 1591)
This is a hybrid with parentage of BLA 139-1 X K 30-1 with jumbo nut size developed and released from CRS, Madakkathara in 1995. The yield of nuts is 16.9 kg/tree. The nut weight is 10.8g with kernel weight of 2.87g. Shelling percentage is 26.5. The export grade of kernels conforms to W 180. Colour of apple is yellowish red. Apple weight is 135g. Apple has 57.4% of juice.

Amrutha (H 1597)
This is a hybrid with parentage of BLA 139-1 x H 3-13 developed and released from CRS, Madakkathara in 1999. It has yield potential of 18.4 Kg/tree with nut weight of 7.2 g. Shelling percentage is 31.6 and with kernel weight of 2.2 g and kernel grade W 210. Colour of apple is yellow and apple weight is 76.0 g. Apple has 57.4% juice content. It is recommended to the state of Kerala.

Sulabha
It is selection released in 1996 with compact canopy and intensive branching. It is bold nut type with 9.8 g nut weight. The tree yields 21.9 kg of nuts with high shelling percentage (29.4%). The kernel weight is 2.88 g and grade is W 210. It bears light orange apples.

Damodar
It is hybrid released during 2002 with a parentage of BLA 139-1 X H 3-13. It has yield potential of 13.7 kg / tree with nut weight of 8.2 g. shelling percentage is 27.3. The kernel weight is 2.0 g and grade is W 240. It bears yellow red apples.

Poornima
It is hybrid released during 2006 with a parentage of BLA 139-1 X K -30-1. It has yield potential of 14.1 kg / tree with nut weight of 7.8 g. Shelling percentage is 31.0. The kernel weight is 2.6 g and grade is W 210. It bears yellow apples.

Raghav
It is hybrid released during 2002 with a parentage of ALGD -1 X K -30-1. It has yield potential of 14.7 kg / tree with nut weight of 9.2 g. Shelling percentage is 26.6. The kernel weight is 2.27 g and grade is W 210. It bears yellow apples.

Varieties released by Cashew Research Station, Anakkayam

Anakkayam-1 (BLA 139-1)
This is a selection from the seedling progeny of Tree No 139 of germplasm collection of Agricultural College, Bapatla, Andhra Pradesh. The variety was released in the year 1985. The variety has a short flowering duration. The yield is 12 kg/tree. The nut weight is 6g and shelling percentage is 28. Colour of apple is pink. Average apple weight is 67.5g. Reducing sugar content is 10%. Kernel grade is W 280.

Dharasree
It is hybrid released during 1996 with a parentage of T 30 X Brazil-18. It has yield potential of 15.0 kg / tree with nut weight of 7.8 g. Shelling percentage is 30.5. The kernel weight is 2.4 g and grade is W 240. It bears yellowish pink apples.

Akshaya
It is hybrid released during 1998 with a parentage of H-4-7 X K -30-1. It has yield potential of 11.0 kg / tree with nut weight of 11.0 g. Shelling percentage is 28.4. The kernel weight is 3.12 g and grade is W 180. It bears yellow apples.

Anagha
It is hybrid released during 1998 with a parentage of T 20 X K -30-1. It has yield potential of 13.7 kg / tree with nut weight of 10.0 g. Shelling percentage is 29.0. The kernel weight is 2.9 g and grade is W 180. It bears orange red apples.

Varieties released from Karnataka

A total of five varieties have been developed and released by ARS, Ullal (Ullal-1, 2, 3, 4 and UN 50). DCR (FormerlyNRCC) has released three varieties (Seln-1, Seln 2 and Bhaskara).

Chintamani-1 and Chintamani-2 were developed and released by ARS, Chintamani, Kolar District of Karnataka for maidan tract of Karnataka.

a) Varieties released from ARS, UAS, Ullal

Ullal-1
This is a selection from the germplasm collected from Taliparamba in Kerala (8/46 Taliparamba) and released by ARS, UAS in 1984. The variety has 2-3% of bisexual flowers. The average yield is 16 kg/tree. The duration of harvest is long (about 110 days). The nut weight is 6.7g with shelling percentage of 30.7%. The colour of apple is yellow. Kernel grade is W210.

Ullal-2
This is a selection from germplasm collected from Guntur in Andhra Pradesh (3/67 Guntur). This variety was also released in 1984. The variety is a late flowering type (December to March) with very short duration of harvest (85 days). The yield is about 9 kg/tree. The nut size is medium with 6g nut weight and shelling percentage is 30.5. Colour of apple is light red. Kernel grade is W 240. This variety is withdrawn from recommendation for cultivation.

Ullal-3
It is a selection from 5/37 Manjeri and released in 1993. It is early in flowering (November - January) and fruiting period is very short (50-60 days). The fruiting is from January to March and sometimes starts from last week of December. It is a high yielding variety with average yield of 14.7 kg/tree. The nut size is medium with nut weight of 7g. The shelling percentage is 30% and the kernel grade conforming to W 210 grade. The colour of apple is red.

Ullal-4
It is a selection from 2/77 Tuni Andhra and released in 1994 for general cultivation. The average yield is 9.5 kg/tree. The nut size is medium with 7.2g nut weight. Shelling percentage is 31%. Export grade of kernels conforms to W 210 counts/lb. The colour of apple is yellow and apple weight is 75g.

UN-50
This is a selection from Nileshwar 2/27 (T.No.25) and released in 1995. This is a medium duration variety. The average nut yield is 10.5 kg/tree. The nut weight is 9g and shelling percentage is 32.8%. The kernels are suitable for export with more than 85% of kernels coming under W 180 export grade. Apple colour is yellow.

b) Varieties from DCR (Formerly NRC-Cashew), Puttur

NRCC Selection-1
This variety was released in the year 1989. This is a selection from segregating progeny of germplasm 3/8 Simhachalam (VTH 107/3) originally a collection from AP. It is a late flowering type (December - February) with a flowering duration of 82 days. The number of fruits per bunch is 5. The yield, on an average, is 10 kg/tree. The nut weight is 7.6g. The shelling percentage is 28.8% and the kernel grade conforms to export grade of W 210. Apple colour is yellow. This variety is withdrawn from recommendation for cultivation.

NRCC Selection-2
This is a selection from the segregating seedling progeny of 2/9 Dicherla (VTH 40/1) originally a collection made from Andhra Pradesh. This variety was released in 1989. It has a mid season flowering habit (November - January) with a flowering duration of 74 days. The number of fruits per bunch is 3. The average yield is 9 kg/tree. The nut weight is 9.2g. The shelling percentage is 28.6% and kernel grade conforms to export grade W 210. Colour of apple is pink.

Bhaskara
This variety was released during March 2006 for coastal region of Karnataka. This is having midseason flowering habit (Dec-Mar) with a flowering duration of 60 days and has potential to escape from the attack of the tea mosquito bug (TMB) under low to moderate outbreak situation. But the regular insecticidal spray against TMB is essential under severe out break situation. The number of fruits per panicle (bunch) ranged from 4 -13. The average yield on 13th year was 10.7 kg/tree with highest yield of 19 kg/tree. The nut and kernel weight are 7.4 g and 2.2 g respectively. The shelling percentage is 30.6 and kernel grade conforms to export grade W240. The apple colour is pinkish orange and juice content is 67.5%. This variety is very popular among the farmers of Dakshina Kannada District of Karnataka and also in neighbouring districts of Karnataka and Kerala.

c) Varieties from ARS, Chintamani

Plains region is characterized by leveled land with very low rainfall. The soil is deep and red sandy loam in nature. The Kolar region has a coordinating centre at Chintamani and two varieties by name Chintamani-1 and Chintamani-2 were released from this Centre.

Chintamani-1
It is a selection from 8/46 Taliparamba, a germplasm collection from Taliparamba in Kerala and released in 1993 from ARS, Chintamani. This variety is recommended for plain region of Karnataka. Its flowering period is from January to April with 2-4 nuts per panicle. The average yield of this variety is 7.2 kg/tree as against the 2 kg/tree of the local varieties. The nut weight is 6.9g with shelling percentage of 31%. The kernel grade is W 210.

Chintamani-2
It is a seedling selection from ME 4/4 of ARS, Ullal and released in 2007 from ARS, Chintamani. This variety is also recommended for plain region of Karnataka. The canopy type is compact and with intensive branching. Its flowering period is from December to January. The average yield of this variety is 12.4 kg/tree. The nut weight is 7.9g with shelling percentage of 30%. The kernel weight is 2.35 g. The kernel grade conforms to W 210. The colour of the apple is red purple with average weight of apple of 70g. Juice content is 60%.

A National Group meeting was convened in 1988 to finalize production strategy of different plantation crops. This group suggested cultivation of several varieties of cashew in different states based on the varietal performance in different regions and their availability. Subsequently several cashew varieties have been released for general cultivation in different states. Some varieties developed in one state/region were found to perform well in other states/regions as well.

The state-wise varieties recommended are given below:

State	Recommended varieties
Karnataka	NRCC Sel-2, Bhaskara, Ullal-1, Ullal-3, Ullal-4, UN-50, Vengurla-1 (Uttara Kannada), Vengurla-4 (Uttara Kannada), Vengurla-7 (Uttara Kannada)
Karnataka (Plains region)	Chintamani-1, Chintamani-2 and Dhana
Kerala	BLA-39-4 (Madak-1), NDR-2-1 (Madak-2), K-22-1, Kanaka (H 1598), Dhana (H 1608), Priyanka (H 1591), Amrutha (H 1597), VRI-3
Maharashtra	Vengurla-1, Vengurla-4, Vengurla-6, Vengurla-7 , Vengurla-8
Goa	Goa-1, Goa-2, Vengurla-1, Vengurla-4, Vengurla-6, Vengurla-7
West Bengal	Jhargram-1, Bidan Jhargram-2, BPP-8
Orissa	Bhubaneswar-1, BPP-8, Dhana
Tamil Nadu	VRI-3, VRI (Cw) 5
Andhra Pradesh	BPP-4, BPP-6, BPP-8
Chattisgarh	Indira Kaju-1

Table 1.Varieties of cashew released from different cashew research centers in India

S.No.	Variety	Hybrid	Year of Release	Nut Weight (g)	Kernel Weight (g)	Shelling (%)	Yield	Export	Remarks
Directorate of Cashew Research, Puttur (Formerly NRCC)									
1	NRCC Sel-1	Selection	1989	7.6	2.10	28.8	10.0	W 210	Withdrawn from recommendation
2	NRCC Sel-2	Selection	1989	9.2	2.15	28.6	9.0	W 210	Short duration and bold nuts
3	Bhaskara	Selection	2006	7.4	2.20	30.6	10.7	W 240	Escapes from the attack of TMB
Cashew Research Station, Anakkayam, KAU,Thrissur									
4	Annakkayam-1	Selection	1982	5.9	1.67	28.0	12.0	W 280	Early, vigorous and short flowering period
5	Dharasree	Hybrid	1996	7.8	2.40	30.5	15.0	W 240	Mid season flowering, compact canopy
6	Akshaya	Hybrid	1998	11.0	3.12	28.4	11.0	W 180	Bold nut type
7	Anagha	Hybrid	1998	10.0	2.90	29.0	10.0	W 180	Bold nut type
Cashew Research Station, Madakkathara, KAU,Thrissur									
8	K-22-1	Selection	1987	6.2	1.60	26.5	13.2	W 280	Compact canopy
9	Madakkathara-1	Selection	1990	6.2	1.64	26.8	13.8	W 280	Early flowering, compact canopy
10	Madakkathara-2	Selection	1990	7.3	1.88	26.0	17.0	W 210	Late variety, high yield
11	Kanaka	Hybrid	1993	6.8	2.08	30.6	12.8	W 280	Mid season flowering
12	Dhana	Hybrid	1993	8.2	2.44	29.8	10.7	W 280	Mid season flowering and cluster bearing
13	Priyanka	Hybrid	1995	10.8	2.87	29.6	17.0	W 180	Bold nut, mid season and drought tolerant
14	Sulabha	Selection	1996	9.8	2.88	29.4	21.9	W 210	Mid season flowering
15	Amrutha	Hybrid	1998	7.2	2.24	31.6	18.4	W 210	Mid season flowering
16	Damodar	Hybrid	2002	8.2	2.00	27.3	13.7	W 240	---
17	Raghav	Hybrid	2002	9.2	2.27	26.6	14.7	W 210	--
18	Poornima	Hybrid	2006	7.8	2.60	31.0	14.1	W 210	---

S.No.	Variety	Hybrid	Year of Release	Nut Weight (g)	Kernel Weight (g)	Shelling (%)	Yield	Export	Remarks
Agricultural Research Station, Ullal, University of Agricultural and Horticultural Sciences, Shimoga, Karnataka									
19	Ullal -1	Selection	1984	6.7	2.05	30.7	16.0	W 210	Long duration, Escapes from the attack of TMB
20	Ullal -2	Selection	1984	6.0	1.83	30.5	9.0	W 320	Short duration, small nuts
21	Ullal -3	Selection	1993	7.0	2.10	30.0	14.7	W 210	Short duration
22	Ullal -3	Selection	1994	7.2	2.15	31.0	9.5	W 210	Short duration
Agricultural research station, Chintamani, UAS, Bengaluru, Karnataka									
23	Chintamani-1	Selection	1993	6.9	2.10	31.0	7.2	W 210	Uniform and attractive nuts
24	UN-50	Selection	1995	9.0	2.24	32.8	10.5	W 180	Bold nuts and high shelling percentage
25	Chintamani-2	Selection	2007	7.9	2.35	30.0	12.4	W 210	---
Cashew Research Station, Bapatla, ANGRAU, Hyderabad, Andhra Pradesh									
26	BPP-1	Hybrid	1980	5.0	1.37	27.5	10.0	W 400	Flush colour is pinkish, semi tall and cluster bearing
27	BPP-2	Hybrid	1980	4.0	1.04	25.7	11.0	W 450	Withdrawn from recommendation
28	BPP-3	Selection	1980	4.8	1.34	28.1	11.0	W 400	--
29	BPP-4	Selection	1980	6.0	1.15	23.0	10.5	W 400	Poor Shelling %
30	BPP-5	Selection	1980	5.2	1.25	24.0	11.0	W 400	Early bearer and poor Shelling %
31	BPP-6	Selection	1980	5.2	1.44	24.0	10.5	W 400	Long duration
32	BPP-8	Hybrid	1993	8.2	1.89	29.0	14.5	W 210	Early bearer
Regional Research Station, Vridhachalam, TNAU, Coimbatore, Tamil Nadu									
33	VRI-1	Selection	1981	5.0	1.4	28.0	7.2	W 320	Suitable for coastal region
34	VRI-2	Selection	1985	5.1	1.45	28.3	7.4	W 320	Wide acceptability
35	VRI-3	Selection	1991	7.2	2.16	29.1	11.7	W 210	Early flowering
36	VRI-4	Selection	2000	6.6	--	28.5	--	W 240	Mid season flowering
37	VRI-5	Hybrid	2009	7.2	--	30.5	13.2	W 210	Cluster bearing

S.No.	Variety	Hybrid	Year of Release	Nut Weight (g)	Kernel Weight (g)	Shelling (%)	Yield	Export	Remarks
Regional Fruit Research Station, Vengurla, KKV,									
38	Vengurla -1	Selection	1974	6.2	1.39	31.0	19.0	W 240	Early flowering and medium size nuts
39	Vengurla -2	Selection	1979	4.3	1.0	32.0	24.0	W 320	Short duration, small nuts and high yield
40	Vengurla -3	Hybrid	1981	9.1	2.09	27.0	14.4	W 210	Bold nuts
41	Vengurla -4	Hybrid	1981	7.7	1.91	31.0	17.2	W 210	Cluster bearing
42	Vengurla -5	Hybrid	1984	4.5	1.0	30.0	16.9	W 400	Compact canopy
43	Vengurla -6	Hybrid	1991	8.0	1.91	28.0	13.8	W 210	More fruiting laterals
44	Vengurla -7	Hybrid	1997	10.0	2.9	30.5	18.5	W 180	Bold nuts
45	Vengurla -8	Hybrid	2001	11.6	--	---	17.5	W 180	Bold nuts
Cashew Research Center, ICAR Research Complex, Goa									
46	Goa -1	Selection	1999	7.6	2.2	30.0	7.0	W 210	
47	Goa -2	Selection	2007	9.4	2.3	29.2	5.5	W 210	Yellow and big apple
Regional Research Station, Jhargram, BCKV, Kalyani, West Bengal									
48	Jhargram-1	Selection	1989	5.0	1.5	30.0	8.5	W 320	
49	Bidhan Jhargram-2	Selection	2014	9.2	2.85	32.0	13.5	W 180	Bold nuts
Orissa University of Agriculture and Technology, Bhubaneswar, Odisha									
50	Bhubaneswar -1	Selection	1989	4.6	1.47	32.0	10.5	W 320	Cluster bearing and high shelling percentage
51	Jagannath	Hybrid	2008	8.6	--	32.5	10.5	--	Mid season flowering
52	Balabhadra	Hybrid	2008	7.4	--	30.0	10.0	--	Early variety
	Cashew Research Centre, Jagadalpur, Indira Gandhi Krishi Viswa Vidyalaya(IGKVV), Raipur, Chattisgharh								
53	Indiara Kaju-1	Selection		10.5	--	28.6	15.5	--	Cold tolerance

ESTABLISHMENT OF CASHEW ORCHARDS

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A) Selection of site and soil management

Great harm has been done to cashew cultivation by notions like "cashew is very modest in its soil requirements and can adopt itself to varying soil conditions without impairing productivity". As a result, the worst soils have always been selected for cashew, where no other crop could give an economic return. As a matter of fact, cashew performs much better on good than on poor soils, but its yield potential has never been tried out on good soils, using the best available plant varieties, fertilizers and pesticides such as those used for other crops to which cashew is compared.

To get fairly economical return from cashew it is always preferable to select proper land suitable for cultivation. It is well known fact that cashew is fairly deep-rooted crop with its active roots concentrated in the first 1 m depth of the soil and 2 m radius around the trunk of the tree. So, soil should be minimum 1.5m deep without any hard laterite substratum or granite or any other hard pan which obstructs root growth.

The best soils for cashew are deep, friable, well drained sandy loam soils without a hard pan as explained above. Presence of water table at 5 to 20 m deep is quite congenial for this crop. Deep red laterite soils are also very much suitable for this crop.

The land should be exposed to sunlight all round the day. The crop comes up well even in the very slopy land also provided proper soil conservation measures are followed.

Soil management

In general the crop received minimum attention by the farmers. The crop is mostly raised in poor soil which require proper management to enrich fertility level.

In the case of slopy land, particularly in Kerala and Dakshina Kannada district of Karnataka the soil is very poor. Owing to frequent exposure to weather conditions, particularly heavy rainfall the top soil is almost completely eroded and the subsoil with poor nutrient reserve is exposed in the elevated and slopy lands. If the crop is planted in such soil the yield/tree is generally poor provided, proper soil management is not followed. The following soil conservation measures can be taken up to improve the soil fertility subsequently.

(i) Filling of natural gullies

The natural gullies formed during the rainy seasons have to be filled up at lower level at regular distances with, boulders and soil and planting of grasses which bind the soil very quickly and reduces erosion of fertile soil. In due course of time the gullies are filled up with soil settled at depressions. If the gully checks, as discussed above, are constructed at regular distances, erosion of fertile soil can be arrested.

(ii) Contour bunding

Depending upon the slope of the land the contour bunds of 60 cm height and 2m width at regular distances can be formed to check soil erosion during rainy season and to conserve moisture during pre-monsoon and post monsoon showers. The distance from one bund to another bund will depend upon the degree of slope. If the slope is more than 25%, the spacing from one contour bund to another is around 8m. The crop can be planted at 8m distance along the contour line to further check soil erosion.

(iii) Terracing

By second or third year of planting terracing of 1.8m radius around the trunk of the plant has to be done by cutting across the slope and spreading below. So that the water received through rain drop, runoff or seepage is absorbed directly to the soil within 1.8m radius around the trunk of the plant to make it available to the root zone. This minimises soil erosion, nutrient loss through runoff etc. A catch pit across the slope at the periphery end of terrace is to be provided for withholding water during pre-monsoon and post-monsoon showers in the slopy area. A small channel sidewise connecting the catchpit is to be provided to drain out excess water during rainy season. If the terracing is done after 3 years the roots of the crop get damaged while levelling. As a result the crop suffers. In the levelled land the base of the plant is raised by applying soil all around wherever there is likelihood of water stagnation during rainy season.

(iv) Growing cover crop

The cover crop seeds like Peuraria phasioloides, Calapagonia muconoides, Mimosa invisa @ 7.5 kg seeds/ha on the contour bunds and also in the interspaces of the main crop at 3 to 4 m distance are to be sown by loosening top soil enriched with farm yard manure with the onset of monsoon. The cuttings of Mucuna bracteata can also be planted at 3 to 4 m distance.

Depending upon the fertility and moisture holding capacity and rainfall the cover crops spread and cover the entire ground within two to three seasons. Excess growth of the cover crop can be cut and the cut materials can be spread at the base of the plant as mulch. The cover crop not only conserves moisture, by checking evaporation and reducing soil temperature but also

improves the soil fertility level by adding organic matter to the soil in the process of recycling. It also fixes atmospheric nitrogen and make available this nutrient to the crop steadily. The cover crop even checks growth of noxious weeds like Eupatorium odoratum and Pennisetum polystechyon by its smothering effect and competition. For the early establishment of cover crop in the beginning, the uprooting of noxious weeds and other jungle growth should be done.

B) Recommended Agro techniques

Till recently cashew plantation received very little attention. An analysis of production figures in India shows that the increase in production has not been proportionate to the increase in area under cashew. Cashew plantations are raised in marginal land where no other crop can give an economic return.

The reason for the low production can be attributed to a large proportion of the plantations consisting of seed sown seedlings under poor management, conceivably the production potential of these plantations is very low.

Cashew can grow on poor or stony soil mainly due to its extensive root development and thereby, increasing greatly the available volume of soil from which it can draw nutrients and water. Reasonable yields are obtained as long as there is sufficient soil between the stones to allow the roots to penetrate and specially if deeper, more favourable soil layers can be reached. Crops with less extensive root system might perish on such soils. Scientific management of cashew orchards has become imperative to increase the production of cashewnuts to the maximum extent possible within the shortest time.

Land preparation, manuring, irrigation, drainage, cultural operations, weeding, mulching, cover cropping, pruning, high density planting and intercropping are some of the important aspects to be considered for improving the production potentials of the cashew orchards.

Land preparation and sowing of cover crop seeds

With the onset of monsoon the land must be cleared of all bushy growth and noxious weeds. Soon after the receipt of pre-monsoon showers the stumps of bushy growth should be uprooted and the noxious weeds are also uprooted when the soil is soft with moisture. Soon after that with the onset of actual monsoon season the cover crop seeds like Calapagonia muconoides or Mimosa invisa or Peuraria phasioloides should be sown @ 7.5 kg seeds per hectare on the contour bunds if the land is slopy and also in the interspaces of the rows of main crop proposed to be planted. The seeds are sown by loosening top soil enriched with farm yard manure.

The pits of 60 cm x 60 cm x 60 cm (lbd) are opened at 7 to 8 metre distance either following square or triangular method. Hedge row system of planting can also be adopted (the distance between rows 10m and between plants within row 5m). The size of pits is upto 1m x 1m x 1m in soils with hard pan or hard laterite substratum. Opening the pits along the contour line is preferred in slopy area. The pits have to be filled with mixture of top soil, compost (5 kg) or poultry manure (2 kg) and rock phosphate (200 g). A small channel above the pit is opened to divert water to the sides during rainy season in slopy lands. The run off water should not accumulate in the pit which causes water stagnation during rainy season.

Planting

Planting is done preferably during the first week of June with the onset of monsoon. The soil in the centre of the filled up pit is scooped out. The polythene bag (containing graft) covering the root and soil is removed carefully and the graft with ball of earth intact is separated. The graft is placed gently in the centre of the pit where soil was scooped out and covered with soil and pressed gently. The graft is planted in such a away that the graft union is above the soil level. Sprouts, if any, below the graft union on the root stock are removed with the help off sharp knife. Plastic ribbon covering the union is removed if not done already. Later mulch is provided at the base around the plant to prevent soil disturbance during rainy season and also to suppress weed growth and conserve moisture in the soil. The plant is then staked by erecting. 1 m stick and loosely tied with coir or plastic string.

After care

Sprouts emerging from the rootstock are removed at regular intervals as and when seen. The graft should be allowed to grow by maintaining single stem upto 0.75 to 1 m height by removing sprouts or side shoots not only below the graft union (stock portion) but also above it (only side shoots on the scion portion are removed allowing apical bud to grow). Staking the plant in the second year also by replacing the spoiled and weak support fixed in the first year with strong stick is necessary. When the plant grows to a height of 0.75 to 1 m with single stem, the graft is likely to lodge due to wind blow and hence it has to be staked in the second year also with a strong support.

The flower panicles emerging later in the season need to be removed during the first two years of growth of the graft to boost up proper vegetative growth and thereby achieving proper height and good canopy. The plants are allowed to flower and fruit from third year onwards.

Weak and criss cross branches are removed leaving 4 to 5 strong ones. The canopy of the plant should be round parallel to the ground and vertically semicircular Jettisoning branches on one side only when noticed should be pruned for providing round and compact shape to the plant (open umbrella shape).

Studies on root distribution of a 10 year old cashew trees revealed that more than 90 per cent of the cashew roots are within 2 m radius and maximum depth upto which roots extended was 9.5 m. But more than 90 per cent of the cashew roots are found within 1m depth. The cultural operations should then be restricted to 1 m depth and 2m radius around the trunk of the tree, so that whatever nutrients applied can go to the root zone. Cashew is commonly grown on slopy land in west and east coasts. Soil erosion and leaching of plant nutrients are generally expected in such situations. To avoid soil erosion terracing and catch pit opening are essential.

Terracing and opening catch pit

In the second and third year, terrace of 1.8 m radius around the trunk of the plant is to be formed in slopy areas by cutting the soil across the slope and spreading below.

A catch pit across the slope at the periphery end of terrace is to be provided for withholding water during premonsoon and post monsoon shower in slopy areas. A small channel connecting the catch pit-sidewise is to be provided to drain out excess water during rainy season.

Manuring

Research findings do indicate that cashew require regular fertilizer application to ensure early and higher yield in new plantation and regular high yields from mature trees. It was reported that a 30 year old cashew tree removes 2.80 kg N, 0.75 kg P_2O_5 and 0.75 kg K_2O per year.

Preliminary trials on nutrient requirements indicated that annual application of 750 g N, 150 g P_2O_5 and 150 g K_2O per tree per year is optimum dose for cashew. It was advised to apply the fertilizer in single dose in post-monsoon season when there is optimum moisture in the soil.

During the first year of planting 110 g urea and 200 g rock phosphate are to be applied. For application of fertilizers, a circular trench of 10 cm depth at a distance of 0.5m from the centre of the trunk is to be opened and the trench should be closed immediately after the application of fertilizers.

In the second year, ⅔ of recommended dose of fertilizer is applied in circular trench of 10 cm depth at a radius of 0.75 m away from the plant and covered with soil immediately.

From the third year onwards, full dose of fertilizers is applied at the radius of 1.5m away from the plant to the circular trench of 25 cm width and 15 cm depth and covered with soil.

Irrigation and drainage

Cashew being a hardy crop with extensive root system can absorb soil moisture from deeper layers and in general the crop is not irrigated. However, in initial stage cashew may require irrigation in summer especially in sandy soils. The experimental results showed that with irrigation cashew yield can be increased to 1.5 to 2 times. For a grown up tree i.e., four years onwards irrigating @ 200 litres per tree once in fifteen days from January to March is beneficial. Drip irrigation right from planting upto seven years @ 60-80 litres per tree once in four days was also found equally beneficial. Care must be taken to see that plants are irrigated only after flowering. Depending upon varietal character irrigation should be started one or two weeks after flowering. Hence, wherever irrigation facilities are available, the crop can be irrigated to get more yield and profit. Cashew cannot withstand water stagnation, flooding or impeded drainage. Adequate drainage should be provided wherever there is possibility of water stagnation.

Weeding

Weeds may compete for nutrients, moisture and also for light with cashew plants. Keeping the cashew orchards free of weeds is one of the important aspects of management. The first round of weeding may be done before heavy rains and fertilizer application (June) and the second weeding may be taken up during fertilizer application which falls normally in the month of August-September. Weeds have to be slashed or uprooted before seed setting in weeds so that multiplication of weeds is reduced considerably. In the initial two to three years of the establishment of graft in the main field, weeds are to be removed 2 m around the plant. The weeds prevailing in the remaining interspaces are to be slashed twice annually.

Mulching

Mulching the cashew plantations with organic matter prevents weed growth, reduce surface evaporation, during summer regulates the soil temperature, improves the soil fertility and also prevents soil erosion. Therefore, green matters obtained during weeding may be utilised for mulching the plantations at the base of the respective trees.

Pruning

Cashew is sun loving tropical tree and does not tolerate excess shade. Providing uniform sunlight to each and every part of the canopy therefore assumes major importance to increase the production. Though regular pruning is not advisable for cashew owing to its exuding gum resins from the cut ends, whenever the trees and branches are over crowded the excess branches may be removed for facilitating uniform and maximum interception of sunlight by the crop canopy.

CASHEW BASED CROPPING SYSTEMS

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Introduction

Cashew takes 8 to 10 years for the canopy to cover the entire area under normal spacing and there is good scope in providing high returns to farmers by adopting intercropping. In hilly regions there is a possibility of soil erosion, nutrient losses and weed growth during initial years of planting. Intercropping is the best option to minimize erosion, nutrient losses and conserve soil and moisture and to realize higher returns from unit area during the early stages of cashew plantation. Pineapple can be grown as a suitable intercrop between two rows of cashew for the first seven years. The spacing to be maintained for cashew is 8m x 8m (156 trees/ha) or 7.5 m x 7.5 m (175 trees/ha) or 10 m x 5 m (200 trees/ha). Growing pineapple in trenches across the slope between two rows of cashew helped to conserves the soil moisture, which in turn increased the yield of cashew (main crop) by 1.5 times compared to cashew alone. Pineapple can be grown as a profitable intercrop under irrigated as well as rainfed conditions in west coast region (Yadukumar *et al.,* 2003). Maize and groundnut can be grown successfully as intercrops in newly planted and two years old cashew orchards (Abeysinghe *et al.,* 2003). Other crops such as Tapioca, Turmeric, Ginger, Cucurbits, Colocasia and Elephant Foot Yam have been found to be suitable intercrops in West Coast region while Colocasia, Brinjal, Groundnut, Blackgram were found to be good intercrops in East Coast region. Weed suppression was best in plots carrying cashew / cassava and cashew / plantation / cassava mixtures with a 50-60% reduction in the frequency of weeding per annum (Adeyemi, 1998).

The term *cropping system* refers to the crops and crop sequences and the management techniques used on a particular field over a period of years. This term is not a new one, but it has been used more often in recent years in discussions about sustainability of our agricultural production systems. You can choose from many different types of crops, and you can plant them in different combinations.

Allelopathy is the release of a chemical substance by one plant species that inhibits the growth of another species.

Double-cropping (also known as sequential cropping) is the practice of planting a second crop immediately following the harvest of a first crop, thus harvesting two crops from the same field in one year.

Intercropping is the presence of two or more crops in the same field at the same time arrangement that results in the crops competing with one and another.

Monocropping, or **monoculture,** refers to the presence of a single crop in a field. This term is often used to refer to growing the same crop year after year in the same field; this practice is better described as *continuous cropping*, or monocropping.

Relay intercropping is a technique in which different crops are planted at different times in the same field, and both (or all) crops spend at least part of their season growing together in

the field. An example would be dropping cover-crop seed into a soybean crop before it is mature.

Strip cropping is the presence of two or more crops in the same field, planted in strips such that most plant competition is within each crop rather than between crops.

Advantage of Intercropping

- Intercropping gives additional yield income/unit area than sole cropping.
- It acts as an insurance against failure of crops in abnormal year.
- Inter-crops maintain the soil fertility as the nutrient uptake is made from both layers of soil.
- Reduction in soil runoff and controls weeds.
- Intercrops provide shade and support to the other crop.
- Inter cropping system utilizes resources efficiently and their productivity is increased
- Intercropping with cash crops is higher profitable.
- It helps to avoid inter-crop competition and thus a higher number of crop plants are grown per unit area.

Disadvantages of intercropping

- Yield decreases as the crops differ in their competitive abilities.
- Management of different cultural practices seems to be difficult task.
- Improved implements cannot be used efficiently
- Higher amount of fertilizer or irrigation water cannot be utilized properly as the component crops vary in their response of these resources.
- Harvesting is difficult.

Challenges in cropping systems

Pests and diseases*:* Certain insect pests and diseases may spread easily from one crop to the next through the crop residues. Avoid crop combinations where this is a problem.

Markets

Markets do not always exist for new crops you may want to plant as part of your rotation. It may be hard to find seed, you can't find anyone to buy the yield, or prices are too low to make it worthwhile growing the crop.

Knowledge, skills and labour

Managing rotations properly requires more skills than a single crop. It also needs work at different times of year. People may be reluctant to try out new crops because they are not used to growing or eating them.

West Coast

Pineapple as intercrop

Pineapple can be grown as an intercrop in cashew garden profitably for the first 7 years. Both main and intercrop can be planted simultaneously. Normally pineapple can be grown in the inter spaces available between two rows of cashew plants planted at 8m x 8m (156 trees/ha) or 7.5 m x 7.5 m (175 trees/ha) or 10 m x 5 m (200 trees/ha). Pineapple is planted with the onset of pre-monsoon showers in three trenches dug out at 90 cm distance across the slope between two rows of cashew. In leveled land straight trenches can be opened between two rows of cashew. Each trench is of 1 m width, 0.5 m depth and convenient length. Pineapple suckers with 8-15 leaves are planted in each trench in two rows at 60 cm apart. The distance between two plants within a row is 40 cm. Before planting pineapple suckers the trench should be half filled with mixture of top soil, farm yard manure and rock phosphate. Nearly 2.5 kg of farm yard manure and 160 g of rock phosphate/metre length of trench should be added and thoroughly mixed. Fertilizers should be applied annually in two split doses (May-June and September-October). Fertilizers are applied at the rate of 25 g N, 7 g P_2O_5 and 25 g K_2O/pineapple sucker/year. Each time whenever fertilizers are applied in September-October period, earthing up of soil at the base of suckers in each row is done after weeding. This operation is most important for pineapple for better anchorage in addition to better rooting. Nearly 35% of the plant population yields in the second year itself. Remaining 65% yield can be realized during the subsequent years. In the fourth year replanting of pineapple should be done in the freshly opened trenches at the adjacent areas between the two existing trenches.

Pepper as inter / mixed crop

Trailing pepper on the stem and branches of grown up cashew trees (more than 6 years) is also adopted. Separate application of manure is necessary for pepper vine. With the onset of monsoon, pit size of 45 cm x 45 cm x 45 cm should be opened about 45 cm away from the cashew tree at the base and pits should be filled with top soil, 200 g rock phosphate, 200 g lime and 0.5 kg neem cake. Rooted pepper cuttings should be planted during June with the onset of monsoon (South-West Monsoon season). Once the vine establishes and starts growing, the vine should be tied to the stem of the tree at the base with jute thread. This practice should continue till vines grow to almost 1.5 m height all around the stem surface of the cashew tree. Cashew stem girth will be around 30 cm when it is 6 years old and because of the rough stem surface of the cashew tree, pepper vine easily clings to the plant and spreads to all the remaining thick branches. This actually when exposed to filtered sunlight through cashew canopy, it flowers profusely during rainy season. From second year onwards regular application of recommended doses of fertilizers in split doses to pepper (100 g N, 40 g P_2O_5 and 140 g K_2O g/tree/year) at 45 to 60 cm away from the base results in better growth and yield.

Ginger as intercrop

Ginger can be grown as an intercrop in the initial 3 to 4 years of cashew plantation. Particularly this is more suitable in the interior areas of west coast on hillocks with forest surroundings. Whenever forest surroundings are noticed growing ginger in the initial years before taking up regular plantation is a common practice in west coast region. With the onset

of pre-monsoon season (April-May) raised beds of 2.5 m length, 1.5 m width and 0.25 m height should be prepared across the slope between two rows of cashew. With this operation all the jungle growth including small bushes will be removed and soil is loosened. Loose and made up soil present in the raised bed, acts as good soil and moisture conservation structure which also facilitates better penetration of cashew roots. Even the weeds will be controlled while preparing beds for ginger. Approximately 10 quintal disease free ginger rhizomes are required as seed material for planting one ha. Rhizomes of ginger should be planted in raised bed at 10 cm distance from one planting spot to another spot.

Farm yard manure or compost at the rate of 15 t/ha has to be applied initially to the bed after planting ginger rhizomes. Soon after planting; thick mulch has to be applied at the rate of 10 t/ha. Application of heavy mulch is necessary to conserve moisture during pre-monsoon and later to avoid soil erosion during rainy season. Heavy mulch also is necessary to conserve moisture soon after the cessation of rain so that this will continue for another 3 months without necessitating irrigation. Ginger crop is of 7 to 8 month duration and harvesting can be done in the month of January. Total cost of cultivation includes items like clearing of jungle, raised seed beds, cost of ginger seed rhizomes, application of FYM and weeding and mulching. One can expect a yield of around 60 quintals ginger per hectare. In the subsequent 2 to 3 years, part of rhizomes removed from the previous crop can be utilized as seed material each year and to that extent the cost of cultivation is reduced. Ginger is prone for deadly disease Rhizome rot, which needs proper care.

Fodder and legume forages

Experiments conducted at Agricultural Research Station, Ullal revealed that among the fodder crops as intercrops, NB-21 grass gave the highest green fodder yield (41.9 t/ha) over Guinea grass (27.6 t/ha) and para grass (18.0 t/ha). Among legume fodders, *Sonthus hamata* ranked first in green fodder yield (12.55 t/ha) followed by *Mimosa invisa* (10.25 t/ha) and *Lupinus* spp. (7.28 t/ha). The unutilized interspace of cashew in coastal Karnataka was successfully exploited for 1st three years of plantations by growing fodder and grasses like NB-21, Guinea grass and para grass with NB-21 yielding highest green fodder of 21 t per ha (Chalapathi, 1989).

Andhra Pradesh

At Bapatla, groundnut, green gram and black gram can be grown as inter crops in rabi season. Groundnut recorded a maximum yield of 1400 kg/ha and had higher cost benefit ratio (1:1.96). Horsegram as an intercrop resulted in net profit of Rs.19900/- with a cost benefit ratio of 1:1.80 (Table 7). Whereas, inter cropping with flower crop like marigold with cashew recorded the highest net profit of Rs.65, 967/- per hectare (Table 8). During the year 2011-12, cluster bean, marigold, amaranthus and mesta were grown as intercrops. Cluster bean recorded maximum yield of 9097 kg/ha and gave higher cost benefit ratio 3.7 and led to maximum net returns of Rs. 94,002/-. In the West Godavari district, cashew is grown in combination with *Casuarina* and coconut.

Tamil Nadu

Among field crops, pulses and oil seeds were attempted as intercrops for cashew. Groundnut performed better as an intercrop in cashew in terms of total returns (Rs. 16,188/- per hectare) whereas, the highest cost benefit ratio for black gram (1:2.1) revealed black gram as a suitable intercrop for cashew (Table 9). Black gram led to the highest C: B ratio of 1:2.1 followed by groundnut (1:1.19). However, groundnut resulted in maximum net profit of Rs.16, 187/ha (Table 10). Further, medicinal plants are also found to be suitable intercrops for cashew. Intercropping of *Aloe vera* with cashew recorded higher BCR value of 4.1. *Ocimum sanctum* intercropped in cashew showed sustained performance for four years and *Aloe vera* + cashew for three consecutive years. Hence, *Ocimum* and *Aloe vera* could be promoted as profitable intercrops in cashew.

Orissa

Vegetable crops such as brinjal, cowpea, chilli, bhindi, pumpkin, colocasia were evaluated for their economic suitability as intercrops with different doses of fertilizer. The yield and total net returns per hectare from inter-crops as well as main crop after 4 years revealed that maximum return was received from colocasia (Rs 66,216/-) followed by bhindi (Rs. 58,155/-), brinjal (Rs. 58,035/-), cowpea (Rs 57,635/-), chilli (Rs. 56,815/-), pumpkin (Rs 52,493/-) and control (Rs 40,075/-) (Table 12).

West Bengal

In the eastern humid region, intercrops such as bottle gourd, *Amaranthus*, pumpkin, cucumber and bitter gourd were evaluated at Jhargram. Maximum yield was obtained in cucumber (10.607 Q/ha) followed by bottle gourd (9.615 Q/ha) and amaranths (5.160 Q/ha). The yield of cashew was only 6.00 Q/ha without an intercrop while it was 9.87Q/ha with amaranthus. . The benefit cost ratio (2.44) confirmed that cashew + bottle gourd was the most profitable practice followed by cashew + amaranths (benefit cost ratio of 1: 1.93) and cashew + cucumber (benefit cost ratio of 1: 1.81). Intercrops such as coriander, dill and fenugreek were grown in open canopy area under 5m x 4m spacing. Maximum yield was obtained from fenugreek (14.77 q/ha) followed by coriander (6.74 q/ha). Significant difference was noticed in the yield of cashew between cashew grown alone and cashew grown with intercrops. The yield of cashew was 1.28 q/ha without an intercrop, while it was more than 2 q/ha with intercrops. The cost benefit ratio (0.41) confirmed that cashew + fenugreek was the most profitable practice followed by cashew + dill (benefit Cost ratio: 1: 0.14). When eucalyptus (*E. teretecornia*) was grown as intercrop in cashew, cashew yield was reduced from 200 g per tree for cashew grown alone to 50 g per tree for cashew grown with eucalyptus. The percentage of TMB infestation on cashew was greater (78.8 per cent) when *Eucalyptus* was intercropped with cashew than sole crop of cashew (20 per cent) (Ghose, 1993).

Madhya Pradesh

Under Bastar plateau zone of Madhya Pradesh, intercrops like cowpeas, bush type French bean, cluster beans, ricebeans, urd beans, moong beans, soya beans and ground nuts grown in 3 year old cashew orchard, recorded higher net returns than sole crop of cashew (Gupta, 1999).

HIGH DENSITY PLANTING AND CANOPY MANAGEMENT IN CASHEW

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High density planting of late became a very popular technology in most of the crops to harness the initial benefits of closer planting in the orchards. In tree crops when go for wider spaced planting lot of space will get wasted, at least for a initial few years. Many occasions, the mixed or inter cropping in the vacant spaces with annual crops species is suggested to cover such spaces and exploit maximum out of the given piece of land. But in crops like cashew as the production is as such very low and requires to meet the demand in short span of time, high density is proved to be an successful venture in the initial few years to achieve higher productivity.

Requirements of high density

For a successful high density orchard an early bearing precocious variety is most essential requirement. The precocious variety's will help to take early benefits of closer spacing. Secondly, the plant should be slow growing, so as to avoid pruning and throwing away the vegetative growth. It was suggested in other crops either (i) a variety should be dwarf and compact, (ii) should be grafted on a dwarfing root stocks, (iii) go for use of growth reducing chemicals or growth retardants or (iv) adopt regular pruning of unwanted growth in order to control the size of the plant within the allotted spaces. As in cashew dwarf types or dwarfing root stocks are yet to be identified or exploited and Paclobutrazol an growth retardant becomes a cost lier affair and also not recommended for want of information on several issues the only option remains is pruning and canopy management.

Studies were conducted on high density planting of cashew at Directorate of Cashew Research, Puttur, Shantigodu since 1996 onward and in coordinating centres in different cashew growing States. The results are quite encouraging. It has been proved that cashew yield can be increased to 4 folds up to 6 years and 2.5 folds up to 12 years if high density planting system of 625 trees/ha.is maintained. The above result was compared with normal density of 156 trees/ha. Details are as follows:

System of planting	Spacing (M)	Density No./ha	4^{th} to 12^{th} year Cum.yield Kg/ha
Normal density	8 x 8	156	2275
High density	4 x 4 upto 11 years and 8 x 5.6 x 5.6 after that	625 upto 11 years and 312 after that	3944

High density planting of cashew is more suitable in less fertile area. Because in area where soil fertility is low growth of the plant is very much slow resulting less ground coverage in the initial years. In such locations if normal density planting with 8m x 8m spacing (156 trees/ha) is done the yield is very low in the initial stages of plant growth.

Economics

It was worked out that the net profit/ha was Rs.77054 in high density planting plot for the first 12 years. Where as in normal density plot (156 trees/plot) the profit was only Rs.26201/ha.

Package for establishing high density cashew orchards

Pits of 100cm x 100cm x 100cm (Lbd) should be opened at 4M distance between two rows as well as in each row between two pits. In slopy area pits should be opened all along the contour line at 4m distance from one row to another row as well as from one pit to another pit within the row. The pits are normally opened with the onset of monsoon so that soil is soft during this period for easier work. The pits should be kept open for a week or so for exposure to sun light to ward off termites, ants and other insects. The pits are then filled with a mixture of top fertile soil, with 8-10 kg organic manure and 200g rock posphate. Cashew grafts of high yielding varieties should be planted in the pits after scooping out 1 spade full of soil in the top centre of the pit. After planting grafts proper staking should be done to avoid breakage in the graft joint due to wind blow. Mulching with dried leaves or green leaves should be done to prevent soil erosion particularly in slopy area during rainy season and also to conserve moisture in summer months. Care must be taken to see that all side shoots coming out below and above graft joint is removed frequently up to 0.45 M from ground level. This is necessary for providing proper shape to the plant with solitary strong stem and for the convenience of cultural operations like weeding, fertlizer and organic manure application, plant protection works and for picking nuts. This also avoids stem borer infection to some extent.

The recommended manurial schedules are as follows. The fertilizers and organic manures in the first year are applied within 50cm radius from the stem of plant @366g urea, 67g muriate of potash and 200g rock phosphate/tree/year. Out of this dose 200g rock phosphate is given at the time of planting graft as explained earlier. The organic manures should also be applied at the time of planting .In the second year fertilizer and organic manure should be applied at 75 cm radius away from the stem of the plant in circular trench dug out (25cm width 15cm depth). The poultry manure @ 2kg/plant should also be applied in the trench and covered with soil. Mulching should be done immediately after the application of manures. Third year onwards full dose of fertilizers and 5kg of poultry manure/ plant should be applied in circular trench dug out 1.5m away from stem of the tree(1100g urea 625g rock phosphate and 200g muriate of potash/plant/year). Manures should be applied soon after cessation of heavy showers (August).

Deblossoming should be done for the first one years to encourage development of proper canopy in case of growth of the plant is not up to satisfaction. Regular shape pruning should be done to achieve umbrella shape canopy with uniform spread .During the first 6 years the crop canopy covers almost 100% of the given ground area. Beyond 6 years because of over lapping of branches thick shade is formed which in turn reduces yield. It is at this stage branches towards the periphery end is cut back by 0.5m radius around to allow 80% of light interception by the crop canopy and remaining 20% to the ground penetrating through gaps in the canopy. Normally pruning is done during August. Soon after this 10% bordeaux paste is applied to the cut ends of the thicker branches. Detopping at 3m height from 5th year onwards is necessary. By 11th year it is necessary to thin out tree population to 50% by removing every alternate tree in each row. Once the canopy has developed pruning of leader shoots (Last years growth) should be done at least once in two years regularly. At

least 60% of the canopy spread should be used for pruning. Length of leader shoot to be pruned should not be less than 8cm and more than 12cm. This will further increase yield by giving out more number of productive lateral shoots which flower in the same year.

Advantages of high density planting is that the weed growth is minimum due to early ground coverage by the crop canopy causing heavy shade over the ground space. This restricts weed growth. Under normal density planting system the trees are at wider spacing leading to maximum exposure of ground area to sun light causing maximum growth of weeds that directly compete with cashew for nutrient and moisture. In high density planting system because of less exposure of ground to sun light the soil temperature during peak summer season is reduced there by reducing soil moisture loss through evaporation. The evaporation from ground surface is also reduced considerably due to heavy deposit of cashew leaves under high density planting system. These leaves when incorporated in soil will be a good source of Nutrients for better plant growth and yield.

Ultra high density planting

Going for much closer spacing with precocious pruning responsive cashew varieties was tried and the results were encouraging. A close spacing of 2.5 M x 2.5 M or 3 M x 3 M which can accommodate 1600 plants or 1111 plants/ha yielded better results and recommendation of this is awaited.

Canopy Management

Cashew like any other wild tree grow very fast with its spreading branches erratically if they are not managed properly. As cashew is highly sun loving plant it requires lot of pruning and thinning of branches to maintain the shape of canopy. If proper pruning and training is done from the beginning the subsequent removal of heavy vegetative growth can be avoided.

Training

Training is a method to direct the plant growth to a desired form. Some of the parts of a plant are pruned with a view to giving the plant a frame work. Support may also be provided. Detopping etc. may also be done. Training is combined with pruning.

- Training is judicious removal of any plant part to give proper shape/to provide a good frame work for the future.
- Training is done in the initial years of planting.
- A strong central stem is allowed to grow.
- Branches are spaced properly.
- The trees are skirted (trunk is kept clean) upto a height of 60-75cm to keep the lower branches off the ground. This should be done every year upto 4-5 years by removing the lower branches.

- The trees are also pruned or detopped to a workable height (5-6m from ground) after 4-5 years of planting.

- During 1st and 2nd year of planting, the flower panicles are also removed to encourage vegetative growth.

- Around the trunk soil mounds may be provided to strengthen the tree's anchorage against cyclonic winds/heavy winds.

- The plants should be provided with staking support during 1st, 2nd and 3rd year of planting.

- Training facilitates easy cultural operations, nut collection, monitoring of CSRB etc.

Pruning

Pruning is judicious removal of unwanted plant parts. When annual growth of a plant are specifically removed, the operation is called pruning. In pruning the form of the tree is not at all affected, but its cropping is highly influenced.

The trees are pruned annually in two ways:

- Thinning - A few shoots or branches that are considered undersirable, are removed entirely without leaving any stub.

- Heading back - Removing the terminal portions of all branches leaving their basal portions intact.

Pruning is done to divert a part of the plant energy from one part to another. When a branch is headed back, the buds below the cut sprout and develop into new shoots. Pruning of any kind, according to its severity, changes the nutritive conditions within the tree and consequently limits or encourages fruit bud formation.

- Heading back may be a good practice for plants in which fruit bearing shoots are produced laterally from basal portions of the previous year's growth.

- Heading back may be disastrous for plants that produce fruit bearing shoots from the terminal portions of the shoots.

- The minimum amount of pruning which is common to all, is the removal of broken or diseased branches, dead wood, dried twigs / branches, criss-cross branches, water shoots / sprouts, crown suckers etc.

- Annual pruning may be very light in the beginning and it may be heavy after some years. Otherwise, the trees may lack vegetative vigour and make very little growth.

- Heavy pruning may extend the juvenility of plants.

a) Water shoots/water sprouts

They are Extraordinarily vigorous vegetative shoots which grow from high points on the main branches in an upright direction at the expense of the parent branches from which they arise. They consume lot of food material. They are much thicker than the normal shoots. They bear much larger and coarser leaves. They grow in such rapidity in one season that they out grow and impoverish the rest of the neighbouring drooping branches of the tree. They are unproductive. If water shoots are not properly removed, they soon close the centre of the tree and obstruct light. They should be removed as soon as they appear.

b) Making pruning cuts

- While removing an entire branch (thinning) the cut should be made close to and even with the outline of the mother limb. No stub portion of the branch should be left on the limb. A clean wound heals smoother and more rapidly.

- While heading back a shoot, the pruning cuts are made between nodes. This results in continued branching and shoot growth. Branches with a diameter of 2cm or less could easily be removed with a secateur, without splitting the shoot/tearing away the bark. Thicker branches can be removed with a garden saw / sickle.

c) Treating of cut wounds

- To avoid fungal infection, to prevent drying of the tissues, and to promote healing of wound (to facilitate the development of callus tissue), the cut surfaces should be treated with Bordeaux paste (10%).

- The wounds under 2.0-2.5cm in diameter need not be treated. The smaller wounds on the tree top may be sprayed with Bordeaux mixture (1%). The wounds greater than 5cm in diameter should be treated with Bordeaux paste (10%).

Training and Pruning in Cashew

Pruning as an horticultural practice was not being followed in tropical evergreen fruit crops for the improvement of yield as the need for such improvement was not felt. Of late, pruning is gaining importance in fruit trees, such as mango, guava, fig. etc. as an orchard management technique to improve the sanitation, easy cultural operations and yield.

In cashew the need for pruning as an orchard management practice is imperative since the nut yield in the existing orchards is very low and demand on the other hand is increasing many folds. The studies conducted at ARS, Ullal, have indicated that removal of dead wood and criss-cross branches from old and unthrifty trees markedly increased the yield. Average yield increased from 1.44 kg/tree before pruning to 2.36, 4.39, 5.53 and 6.08 kg/tree during the first, second, third and the fourth years of pruning respectively. Therefore, there is a need for pruning cashew trees once in 2-3 years.

Studies conducted at NRCC Shanthigodu on the effect of time and severity of pruning in cashew trees of 12-13 years old indicated that the leader shoot pruning done in July and August will help in doubling the nut yield. This has resulted in the production of higher number of lateral shoots and higher number of bisexual flowers per panicle.

a) Training of young cashew plants

Training in cashew should be limited to the removal of criss-cross branches, branches with narrow crotches to facilitate proper light penetration and development of strong scaffold branches to give the young tree a uniform crown around the stem. The lower branches on the main stem are to be gradually removed in the first 2-4 years to a height of 60-75 cm from the ground level.

b) Pruning of old cashew trees

As the age of the tree advances the productivity goes down due to the fall in the vigour of the plant. At that stage severe pruning helps in the production of more vegetative growth which results in higher yields.

Leader shoot pruning

In a large tree about 60 per cent of the leader shoots are to be pruned in May-June by heading back to 2/3rd of the length. Along with this the water sprouts, criss-cross branches, dead and dried shoots are to be pruned by thinning. Pruning of leader shoots should not be carried out every year as this may lead to over exhaustion of the tree which is already weak. Hence, pruning may be taken up once in 3 years.

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REJUVENATION OF OLD CASHEW ORCHARDS

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Introduction

Mostly old cashew plantations are seedling origin and have become senile. Further, cashew plantations raised from grafts of varieties not recommended for the region also give low yield. The technique for rejuvenation of unproductive trees has been standardized by beheading the healthy trees at 1 m height in the month of March. Thereafter, large number of new sprouts will emerge but retain only 4-6 healthy branches considering all directions, so as to develop a good canopy structure and rest should be thinned out. These new sprouts after attaining appropriate size should be top worked by softwood grafting of desired scion shoots. Whereas, frame working can also be done by heading back of major branches from near the site of its origin leaving the main tree frame as such followed by the similar grafting operation. In case of 10-15 years old cashew plantations, highest success rate (80%) in the month of April followed by June grafting (77.08%). In case of 5-10 years old plantations, grafting in the month of June (70%) was better followed by grafting in May (55.3%). Top worked trees start flowering and fruiting in the very next year after grafting with new vigor. May-June is the right time for beheading and July-August is for grafting. However, precaution needs to be taken to monitor each plant for the attack of cashew stem and root borer on the top worked trees.

Rejuvenation

Redevelopment of canopy is possible by heading back or by limb pruning of existing senile tree which have exhausted canopies and erratic growth resulting in reduced yield. Heading back is done at 1.0-1.5 m height of the trees, new flushes emerge from dormant buds on remaining trunk and develop into vigorous new canopy. The new vigorous canopy develop in to a productive growth within 6-10 months depending on the variety/ genotype and hence it should be attempted immediately after the harvest of the crop yield (May to June) so as get normal yielding in ensuing fruiting season. It was noticed that cashew stem and borer (CSRB- Plocaedeerus ferruginous) problem get worsened with beheading of trees. The shot hole borer also starts feeding on the cut trees. Thefore, sufficient precautions are to be taking up before taking up limb pruning in cashew.

Following steps be considered while rejuvenating old trees

- Prior survey of the plot to see suitability of the plants for rejuvenation to be done. If several plants in the plot infected with CSRB damage the rejuvation may not possible.
- If a few plants have damage in the initial stage, remove the CSRB grub and treat the plants with insecticide before taking pruning.
- Prior to beheading swab damage in the trunk chlorpyriphos (0.2%) to prevent the damage and 2-3 times after beheading at regular intervals of a month till new canopy develops.

- Regular checking for prevention of CSRB damage required.
- Pruned ends of branches are smeared with 10 per cent Bordeaux paste to prevent the gummosis and entry of pathogen. Best season for heading back of the old tree is May – June *i.e.* after the harvest of the crop.
- The new flushes come out from the dormant bund on the trunk. These sprouts need be protected from insect pests (mostly sucking pests and leaf beetles and caterpillars) in the initial stage by applying suitable insecticide such a monocrotophos (0.05%) and lamda-cyhalothrin (0.003%).
- Good phytosanitary measures should be adopted to manage the rejuvenated trees.
- Plantation of commercial varieties where the canopy become over crowded resulting in reduction in yield can be rejuvenated followed by canopy management.
- Older plantations of seedling origin which have become senile can be adopted for top worked by grafting with scion of superior varieties to upgrade seedling plantation with superior commercial varieties.

Causes of low yield in old and senile orchards:

- Most of the old cashew orchards are dense and over-crowded and their bearing is low due poor light interception.
- They harbour various pests and disease causing agents due to change in micro-climate inside the canopy.

Advantage of rejuvenation in plants

- Better circulation of air and sun light in to plant canopy.
- Control of pests and diseases much more efficient by the chemical spray.
- Converting sunlight in to fruits or improving fruit quality.
- Increasing the carbon exchange rate in plants.
- Easy agricultural practices in the orchard

Top working

It is the method of changing the upper or aerial portion of plant through the use of grafting techniques is called top working. Generally, old cashew plantations are of seedling origin and they would have become senile. Such plantations can be rejuvenated by top working on flushes from beheaded trees. Trees rejuvenated by top working start flushing and fruiting in the very next season with vigorous canopy growth.

Requirement for top working

- Tree should be young enough (15-20 years) to produce new flushes, preferably tree should have smooth and brown colored bark.
- Tree should not have the infestation of CSRB.
- Tree should be healthy with well developed branches and root system.
- The trees that are selected to be top-worked need to be 'healthy' and in a site that has no problems such as poor drainage.

Benefits of top working

- Shorter time for trees to come into bearing.
- Avoidance of replant problems and an already established root system.
- Mature plants producing inferior quality fruits can be made to produce high quality fruits.
- Improved varieties can be introduced into farms of those already having fairly old orchards without destroying the old trees.
- These trees bring out many shoots, which can be grafted to produce many fruits in two to three years.
- Many varieties can be grafted on a single tree at any one time.
- It is usually done in the spring, shortly before new growth starts.

Selection of the old trees for top working

Top working is most successful when done on relatively young trees where the branches to be grafted are larger than 7.5 to 10 cm in diameter and are relatively close to the ground. It is important that the branch to be top worked is cut in such a location that the region below the cut is smooth and free from knots or small branches, so that there will be enough space for inserting the graft material.

Steps of top working

- Remove branches, except a few vigorously growing ones (referred to as sap drawers or nurse branches), which are left to supply food to the rest of the tree.
- Plant branches should be cut with petrol chain saw to avoid bark splitting.
- New shoots/branches develop and grow.

- Allow new branches to sprout
- Remove new branches leaving 2-4 strong and healthy looking, suitable for grafting.
- Get grafting materials from varieties of your choice and graft them onto the branches that remained.
- The cycle can be repeated until all the existing branches on the tree needing improvement have been replaced with the new varieties.

Irrigation

Cashew is generally grown under rainfed conditions. Although cashew is a hardy and drought tolerant crop, it responds very well for irrigation. Whenever irrigation facility exists it is preferable to give supplementary irrigation during summer months and after rejuvenation of old and senile cashew of fortnightly intervals @ 200 litres/plant which was proved to increase the number of healthy sprouts and nut yield.

Fertigation

Fertilizers and manures promote growth of the plants and advance the onset of flowering in cashew. Application of 10-15 kg of farm yard manure or compost per plant is beneficial. The general fertilizer recommendation for cashew is 500 g N (1.1 kg urea), 125 g P_2O_5 (625 g rock phosphate), and 125 g K_2O (208 g muriate of potash) per adult plant per year.
Pest management in the rejuvenated trees:

The trees which have been top worked need to be checked for any symptoms of CSRB pest incidence right from the first week after top working at 15 days intervals. Normally the fork regions and the cut ends (if uncovered) will have the pest entry and exudation of the fine frass material in small quantity. These spots of the bark should be chiseled cautiously so as not to make more damage onto the bark of the top worked trees and the tunnel made by the grubs, which bore into the bark, can be traced out by the freshness of frass. The young grubs remaining inside need to be removed out and killed. In case the frass comes out from the root zone then the soil at that spot need to be dug out and the infested root needs to be checked for the grubs which are normally found in the underside (ventral) portion of the roots.

The direction in which the grub has moved in both the stem and root can be made out by the freshness of frass wherein the older frass is dark brown and the fresh frass will have reddish colour. In case the grubs are not removed when they are young they damage the bark severely and later enter into the heartwood during which time the frass comprises of whitish fibrous powder. The grubs have to be killed under these situations using a pliable wire or gear wire as the tunnels will be zigzag in nature. A slushy sound is heard as soon as the grubs get poked with the wire and the body fluid oozes out of the tunnel.

The chiseled surface needs to be treated using either carbaryl suspension (1.0%) or chlorpyriphos solution (0.2%). Repeated infestation of treated top worked trees is not uncommon. Hence constant vigil of these trees and those immediately next to it is of utmost importance during the months of Jul. to Nov. when the symptoms of infestation like frass and

yellowing of the shoots is noticed. In certain cases where water logging occurs at the collar region the bark starts rotting at the collar region and the tree likely be attacked severely by the shot hole borers. In such cases, there is an immediate need for treating such trees by swabbing and drenching with monocrotophos (0.2%) (Approx. 2-4 lts per tree) as such trees will lead to spread of infestation to the neighbouring trees in a short time.

SOIL AND WATER CONSERVATION IN CASHEW

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Soil and water conservation activities are an essential part of the cashew production technology followed in slopy areas where the top soil and surface runoff have to be conserved. Most of the cashew plantations in India were was also established on degraded slopes with poor fertility. Although soil and water conservation measures are advocated but most of the farmers continue to grow the crop without adopting conservation measures such as bunds, terraces, catch pits etc. Cashew is usually grown as a rainfed crop. In the west coast, cashew is mostly grown on hilly slopes, where the top soil is eroded completely leading to exposure of subsoil. Due to lack of soil conservation measures, the most fertile top layer of soil is lost through erosion. Adoption of soil and water conservation measures reduces the runoff, soil loss and nutrient loss and increases the soil moisture content and groundwater level. Water deficit during fruiting season ranges from 59 to 183 mm in West Coast with maximum noticed from March to May whereas in East Coast 90 to 155 mm with maximum in March-April. This water deficit in East Coast as well as West Coast shows the need for moisture conservation and or irrigation. *In situ* soil and water conservation is one of the effective methods for harvesting the pre-monsoon and post-monsoon rainfall and make it available to the cashew plant during this critical period.

In the beginning cashew was introduced for soil and water conservation purpose. Now, adoption of cashew in large scale will generate rural employment related with its nut collection and processing and aid in sequestering carbon in the soil. There is a possibility of increased production of cashew by adopting soil and water conservation measures with high yielding varieties of cashew. With proper soil and water conservation practices, the soil loss can be minimized; the runoff water from post-monsoon and pre-monsoon rainfall can be harvested and make available to the plant during the critical period.

I. Soil and Water Conservation in West Coast

Planting of cashew grafts in bigger pits and application of mulch

Opening of pits of size 1 m x 1 m x 1 m. Filling of pits to 2/3rd with soil mixed with organic manure and rock phosphate. This improves the moisture and nutrient availability in its root zone during initial years and creates loose soil for the roots to penetrate. After planting, proper mulching needs to be done. Mulching reduces the evaporation loss, enhances moisture conservation and improves the nutrient status.

Normal tree base terrace at 2 m radius around the plant or reverse terrace

Tree base terrace at 2 m radius around the plant within three years of planting is beneficial in conserving soil moisture. Terrace (2 m radius) should be taken up around each plant by cutting soil from the upper portion of the slope and filling the lower portion so that soil around the plant is flattened. Terrace should be in such a way that the upper side of the slope should have a depression or a catch pit measuring 2 m length, 0.3 m width and 0.45 m depth. Reverse terraces of size 2 m length and 2 m width by cutting soil from the upper portion of the slope and filling the lower portion is also effective in conserving moisture and increasing yield.

Individual tree base terrace with crescent bund at 2 m radius

Terrace at 2 m radius at the base of the plant and making a semi-circular bund of size 6.2 m length, 1 m width and 0.5 m height around each plant on the upstream side of the slope by cutting soil from the upper portion of the slope and filling the lower portion so that a trench of size 6.2 m length and 0.5 m depth will be formed on the upstream can store around 800 to 1000 litres of water during pre-monsoon and post-monsoon showers. Soil and water conservation measures such as modified crescent bund and coconut husk burial treatments increased the growth of cashew plants and cumulative cashew yield indicating 32 to 35% increase in yield. These treatments reduced the annual runoff (20 and 22% of the annual rainfall compared to 37% of the annual rainfall in control) and soil loss (47 and 49% of control), increased the mean soil moisture content (15.6% and 15.8 % dry basis compared to 11.6% dry basis in control in March), nutrient content of the soil and leaf. The harvested rainwater increased the ground water level in nearby wells and ponds. The barren land even in steep slopes can be effectively utilized for cashew cultivation with proper soil and water conservation measures like modified crescent bund or coconut husk burial in staggered trenches opened across the slope.

Coconut husk burial around cashew plants for improving water holding capacity

Coconut husks are to be buried in trenches of 1m width, 0.5m depth and 3.5m length opened across the slope between two rows of cashew. Three to four layers of coconut husks are to be buried one above the other with convex side of the first layer of the husks touching the ground After spreading a layer of leaf materials (if available) and a thin layer of soil (around 2 cm) on the first layer of husks, the second layer of husks are to be laid in the same fashion as that of first layer The last layer of husks should be inverted so that convex side is facing the upper side. Thick layer of soil upto 10 cm thickness should be spread over this Burial of coconut husks enhances soil and moisture conservation and serves as a source of potassium. Besides proper soil and water conservation measures, mulching with coconut husk burial in trenches conserves more moisture and coconut husks serves as a source of potassium.

II. Soil and water conservation measures for East Coast

In East coast, cashew is mostly grown in plain area where the soil is sandy loam, red sandy loam or laterite soils.

- Digging the basin area or ploughing the ground between two rows of cashew before summer rains enhances absorption of rain water.
- Providing thick mulch will helps in reduction in evaporation and conservation of soil moisture and enhances the nutrient status.
- In level area, coconut husks can be buried in circular trenches (0.3 m width, 0.5 m depth) opened at 2 m away from the trunk of the plant.

- Coconut husks can be buried layer wise and thick layer of soil is spread over this. Thick layer of leaf litter and a layer of soil in between two layers of coconut husks can also be buried in the same trench.

Advantages of soil and water conservation

- Catch pits help in harvesting, retaining and making the water available to the plant for a prolonged period and prevents soil erosion. Top soil eroded from the exposed portion of the hillocks also gets deposited in the catch pit.

- In situ moisture conservation in catch pits results in moisture availability to the cashew plant for an additional period of 15-20 days during pre and post monsoon periods.

- Availability of soil moisture during peak flowering and fruiting seasons retains more fruits resulting in higher yields. At least, 25-30 % increased yield can be obtained by adopting soil and water conservation measures in cashew.

NUTRIENT AND IRRIGATION MANAGEMENT IN CASHEW

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I) Nutrient Management

Soil

In India, cashew is grown mainly on laterite, red and coastal sands in the states of Kerala, Maharashtra, Goa, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. It is also grown on black soils in Tamil Nadu and Andhra Pradesh to a limited extent. Although it is grown in almost all types of soils, it performs better in well drained, brown forest soils, red sandy loam and light coastal soil with a high water holding capacity and rich in organic matter. Bulk of the cashew growing soils in India are lateritic, red and coastal sands which are acidic in nature and poor in soil fertility. The runoff and soil erosion are very high in steep slopes. The deficiencies of nitrogen, phosphorus, potassium, magnesium, zinc, boron and molybdenum are on the rise in cashew growing soils.

Nutrient removal

As cashew is a hardy plant, often it has been thought to be highly suitable for afforestation, soil conservation and waste land development. The cashew plantations raised with this objective, did not receive any management nor inputs, thereby resulting in low productivity. However, research results showed that tremendous positive response can be obtained through regular applications of fertilizers and improved management practices which could give two to three fold yield increases. Cashew requires regular fertiliser application to ensure early and high yields in new plantations, and regular high yields from mature trees. A considerable amount of nutrients is removed annually by the cashew tree. The amount of nutrients removed by a cashew tree (30 year old) are listed in Table 1. The analytical results also revealed that in production of one kg of cashewnut, 64.1 g N, 2.05 g P, 24.7 g K, 4.19 g Ca, 1.57 g S, 525.7 mg Fe, 63.6 mg Mn, 87.8 mg Zn and 26.5 mg Cu per tree is removed by the apple and nut (Beena Bhaskar *et al.,* 1995).

Table 1. Estimated removal of nutrients (kg/tree) by a cashew tree

Plant parts	N	P (as P_2O_5)	K (as K_2O)	Average NPK ratio
Leaf, stem and root	1.721	0.406	0.800	4 : 1 : 2
Fruit (155 kg)	0.370	0.117	0.282	3.2 : 1 : 2.4
Nuts (24 kg)	0.756	0.229	0.183	3.3 : 1 : 0.8
Total	2.847	0.752	1.265	3.8 : 1 : 1.7

Source: Mohapatra *et al.* (1973)

Nutrient requirement

The fertilizer requirement of cashew plant warrants more liberal application of N followed by K, while P is needed in comparatively lesser quantity. Nitrogen and P were found to be the most important nutrients during the pre-bearing stage, but at the bearing stage, K together with N is also important. The recommended dose of fertilizers for cashew for major producing states is given in Table 2. Based on the initial fertility status of soil, nutrient dose may vary from location to location. About 10 to 15 kg farmyard manure (FYM)/plant/year is recommended in addition to primary nutrients (N, P and K).

Table 2. Recommended dose of Fertilizers to Cashew

State	Nutrient dose for mature cashew plantations (5th year of planting) (g/tree/year)		
	N	P_2O_5	K_2O
Kerala	500 750	125 325	125 750
Karnataka	500 500	250 125	250 125
Tamil Nadu	500	200	300
Andhra Pradesh	500 1000	125 125	125 125
Maharashtra	1000	250	250
Odisha	500	250	250
West Bengal	1000	250	250

Source: Compiled from DCR, Puttur and AICRP-Cashew Centres

Studies conducted at ICAR-Directorate of Cashew Research (DCR), Puttur indicated that application of 500 g N and 125 g each of P and K and 10 kg poultry manure per tree per year under normal density planting system (10m x 5m; 200 trees/ha) and 250 g N and 50 g each of P and K and 10 kg poultry manure per tree per year under high density planting system (4m x 4m; 625 trees/ha) is found superior in terms of higher nut yield for rainfed cashew in Karnataka. In high density planting system of cashew, the fertilizer recommended is reasonable up to 80-100 per cent canopy coverage which is normally achieved during the initial 6-8 years after planting. After certain stage of the crop, reduction in recommended doses of fertilizers per plant may be necessary due to the nutrient build up in soil due to the deposit of cashew biomass fall out.

Time and method of fertiliser application

The key to enhance fertilizer use efficiency is to synchronize the time of fertilizer application with the growth need of the crop and period of high root activity. Highest root activity and peak absorption of N, P and K occurred during the 'flushing and early flowering' phase (September to December) and suggested that the onset of this phase is the most appropriate time for fertilizer application in a cashew orchard. The annual dose of fertilizers to cashew are to be applied in two split doses, the first split dose at the onset of the monsoon period and the second split dose during the post-monsoon

period when the soil moisture condition is at its optimum; if only one application is given, it should be in the post-monsoon period when enough moisture is available.

Cashew trees are surface feeders with about 50% of the root activity being confined to the top 15 cm of the soil and about 72% of root activity was found within a 2 m radius from the tree trunk (Vidyachandra and Hanumashetti, 1984). This suggested that application of fertilizers within a radius of 2 m from the main stem results in efficient utilization of the applied nutrients. During the first year of planting 1/3rd of recommended dose of fertilizers are to be applied. For application of fertilizers, a circular trench of 10 cm depth at a distance of 0.5m from the centre of the trunk is to be opened and the trench should be closed immediately after the application of fertilizers. In the second year, ⅔ rd of recommended dose of fertilizer is applied in circular trench of 10 cm depth at a radius of 0.75 m away from the plant and covered with soil immediately. From the third year onwards, full dose of fertilizers is applied at the radius of 1.5m away from the plant to the circular trench of 25 cm width and 15 cm depth and covered with soil.

Integrated nutrient management

Organic manure must be applied at planting, addition of farmyard manure (FYM) at a rate of 6 t/ha provides for the better growth of young plants. In studies on integrated nutrient management in cashew conducted at ICAR-DCR showed that application of 500 g N and 125 g each of P_2O_5 and K_2O and 10 kg poultry manure per tree per year under normal density planting system (200 trees/ha) and 250 g N and 50 g each of P_2O_5 and K_2O and 10 kg poultry manure per tree per year under high density planting system (625 trees/ha) is found superior in terms of higher nut yield for rainfed cashew. Green leaf manuring with glyricidia and sesbania in cashew resulted in higher nut yield and improvement in soil nutrient content. The glyricidia contributed 186 kg N, 23.6 kg P_2O_5 and 126.2 kg K_2O/ha and sesbania contributed 141 kg N, 17.9 kg P_2O_5 and 162.3 kg K_2O/ha (Yadukumar *et al.,* 2008). The use of biofertilizers is of relatively recent origin. Application of *Azospirillum*, *Azotobacter* and Vesicular Arbuscular Mycorrhizae (VAM) increased the germination percentage of nuts and plant growth, and reduced the incidence of fungal diseases in the nursery (Kumar *et al.* 1998).

The amounts of nutrient elements recycled in canopy fallout may partially meet the nutrient requirements of cashew. About 15.5–37.7% of tree total requirements of macro-nutrients are recycled from canopy biomass fallout of leaves, cashew apples and flowers from six year old cashew trees in Australia (Richards, 1993). Studies conducted at Directorate of Cashew Research, Puttur on nutrient budgeting and nutrient balance in a six year old cashew plantation of 'Bhaskara' variety under high density planting system (625 trees/ha) showed a negative N, P and K balance of 113, 38 and 92 kg/ha in control plot where no fertilizer was applied. A strong positive N, P and K balance ranged from 128 to 253, 18 to 54 and 34 to 128 kg/ha were recorded in plots with 2/3rd and full dose of recommended fertilizers (750 g N and 150 g each of P_2O_5 and K_2O per tree/year).

Organic production of cashew offers immense potential. Cashew plantations have vast potential of organic biomass available for recycling. The availability of cashew leaf litter from different age group plantations (10 to 40 years) ranged from 1.38 to 5.20 t/ha. Vermicomposting of cashew leaf litter and apple by using local earthworm *Eudrilus*

spp. has been standardized at DCR, Puttur. About 5.5 tonnes of available cashew biomass waste per ha can be converted into 3.5 tonnes of compost or vermicompost and helps in meeting nutrient requirement to cashew by 50%.

II) Water requirement, time and method of irrigation

Cashew tree is considered drought resistant to some extent and is generally grown as an unirrigated crop, but the yield can be doubled, if irrigated. Low productivity is the main concern in cashew cultivation in India. Of several factors associated for such low yields, the low moisture availability during the fruiting season which normally coincides with the onset of dry season in the cashew growing areas is one of the factors. Field experiments conducted at ICAR-DCR on fertigation in cashew indicated that under normal density planting system (7 m x 7 m), the effective canopy coverage per tree is 12.56 m^2. The quantity of irrigation water calculated based on the effective canopy area was 12.56 L/tree/day from December to January (Daily open pan water evaporation is 5 mm) and 20 L/tree/day from February to March (Daily open pan water evaporation is 6.5 mm) to meet 20% of the cumulative pan evaporation (CPE). Similarly, for 40% CPE and 60% CPE, the irrigation rate was 24 L/tree/day and 38 L/tree/day from December to January and 36 L/tree/day and 58 L/tree/day from February to March, respectively. In order to meet 20% CPE, four drippers of 2 L/hour discharge rate can be fitted at two equidistant points 1 m away from the base of the tree. Similarly, to meet 40% and 60 % CPE, four drippers and six drippers of 4 L/h discharge rate can be fixed. Drip irrigation can be given for 1 h 30 min during December and January and 2 h in February and March.

Case study for estimating water requirement of cashew tree to meet 20% CPE

Age of the tree : 5 years
Canopy spread : 4 m, Canopy spread = canopy diameter = mean of EW and NS length
Canopy area = πr^2 where r = radius of the canopy.

If the radius is 2 m, the total area covered by individual tree canopy is 3.14(π) x 2^2 = 12.56 m^2 (Ground coverage by canopy)

Daily CPE = 5 mm, 20% of CPE = 1 mm, Therefore, quantity of water to be given to meet 1 mm of water in 12.56 m^2 area = 12.56 x 1/1000=0.01256 cubic M, 1cubic M =1000 L. Therefore, 0.01256 cubic M =12.56 L/tree/day. Like this quantity of water required to be given is calculated depending upon canopy coverage and daily water evaporation

Fertigation

The application of fertilizers through the irrigation water (fertigation) has the advantages of increasing the efficiency of the fertilizers and reducing the costs of labour and machinery for its application. Fertigation allows the application of nutrients with greater frequency, without increasing the cost of the application, minimizing losses by volatilization and leaching and optimizing nutrient absorption by the roots.

The nutrients most frequently applied in fertigation are those with greater mobility in the soil.

Water soluble fertilizers like urea, diammonium phosphate and muriate of potash are used for fertigation through drip lines from December to March and application of 2 kg castor cake to soil during August. Fertigation is done once in a week from December to March. With fertigation quantity of nutrients (through fertilizers and organic manures) to be applied can be reduced to half of the quantity of recommended nutrients. An increase of 100% and 226% in yield was observed in treatment receiving half of recommended dose of NPK in inorganic form (Recommended dose: 500 g N, 125 g each of P_2O_5 and K_2O/tree/year) of nutrients through fertigation and balance half applied in organic form through castor cake as compared to the above dose through soil and separately irrigated and absolute control (without manure and irrigation) respectively indicating better nutrient use efficiency. Highest profit of Rs.27,294/ha (with B:C Ratio of 3.71) was obtained with the application of half of recommended dose of nutrients through fertigation and balance half applied in the form of castor cake to soil, while the profit was Rs. 8,995 when the NPK dose was given to soil (Yadukumar *et al.,* 2009).

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CASHEW STEM AND ROOT BORER – A MAJOR PEST OF CASHEW

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Cashew farmers experience several hardships in cashew cultivation due to variation in climate, rainfall and also due to severe insect pest incidence which finally leads to significant loss in nut yield. In cashew, several insect pests attack during various stages of the crop and result in moderate to heavy loss of the crop yield depending on level of insect pest population. Out of these pests, two are major insect pests cause considerable yield loss in most of the cashew growing regions of our country. These are a) Tea Mosquito Bug (TMB) scientifically known as *Helopeltis antonii* and b) Cashew Stem and Root Borers (CSRB) scientifically known as *Plocaederus ferrugineus* and *Plocaederus obseus*.

The adults and nymphs of TMB suck plant sap and lead to drying up of shoots and flower panicles, leading to considerable loss during that cropping season. However, incidence or absence of the pest varies over the years. The other pest, cashew stem and root borers infest the vital bark portion of yielding cashew trees and lead to gradual death of such infested cashew trees. The pest population of CSRB increases over the years resulting in constant loss of tree population. Thus, productivity in a given location gets reduced over the years.

In this brochure, the symptoms of infestation and various approaches to be adopted for managing this pest is mentioned for the benefit of the cashew farmers of the country.

What is cashew stem and root borer?

The insect is normally noticed by cashew farmers at larval stage which feeds on the bark portions of the stem and roots, by making irregular tunnels which enlarge as the larva grows in size. The farmers can notice larvae, pupae and unemerged immature adults in the damaged portions of infested trees. The adult insects belong to the “beetle” group of insects which have hard and stout body and are strong fliers. The adult beetles of this group have long antennae and are active during the night. Hence, these adult beetles are normally not noticed in the cashew plantations during day time.

What are the symptoms of pest damage?

At the base of the CSRB infested tree, gum and fibrous material are exuded in small quantities in the initial stage of attack. During later stages of attack, the infested tree canopies show a sickly appearance and the green leaves turn yellowish and start dropping prematurely. In the severe stages of attack, the twigs dry off and the bark on the trunk starts splitting. At this stage, large quantity of chewed fibers and gum (commonly known as frass) are seen as big lumps at the base of the CSRB infested tree.

When does the pest incidence occur?

Normally the pest incidence is noticed during the months of Dec. to May in different cashew growing tracts of the country. Different stages of infestation are generally seen all round the year. However, certain stages of the pest are noticed in certain months only. During the onset of rainy season the healthy trees turn dark green, whereas, the infested trees remain yellowish, which is a sure indicator of the pest attack in those trees. During the nut collection period, close observation of the tree bases reveals the initial infestation symptoms which can be treated suitably prior to onset of monsoon.

How does the pest damage the cashew trees?

The adult female beetles lay eggs (which resemble rice grains) inside the crevices of the bark of stem or exposed roots. Young grubs hatch from these eggs in 5 – 7 days and immediately start boring into the bark. The grubs feed voraciously for a period of 6 to 8 months and grow rapidly in size and fill the tunnels with chewed fibre and excreta. Their zigzag feeding interferes with movement of water and nutrients in the tree trunk and root zone leading to premature leaf fall, drying of branches and gradual death of the tree. Full grown larvae make tunnels in the heart wood and form a hard cocoon made of calcium secretions. The pupae stay inside these cocoons for 60 – 90 days and adult beetles emerge from such cocoons and continue the life cycle.

What are the insecticides which can manage the pest?

Several insecticides have been evaluated at various research centers, for over a decade. Some of the insecticides have been recently banned / being withdrawn and hence, alternate effective insecticides were evaluated later on. It is to be noted that any insecticidal treatment without removing the pest stages will not be effective.

The pest stages of CSRB in the infested cashew trees (both in the stem region and in the root zone also) have to be carefully removed by skillful chiseling of the tunnels in the infested portion and destroyed. The larvae will be present on the fresh fiber portion of the tunnels both in the stem and in the roots. The fresh fiber in the tunnels can be traced by their light color while, older fibers will be darker. In case the larvae have entered into the heartwood for pupation, they can be killed by inserting a gear wire / any other bending metal wire and poking into the tunnel till a slushy sound is heard or white fluid flows out. After removing or destroying the larvae and other pest stages, the chiseled portion should be swabbed thoroughly with chlorpyriphos (0.2%) solution and the same needs to be drenched onto the soil near the root zone. This has been proven to minimize the re-infestation by the pest.

Repetition of the treatment should be done, if fresh pest infestation symptoms occur after 30-45 days. Another point to be borne in mind is not to damage more than 50 per cent of the bark circumference, as this will lead to girdling and death of the treated tree. In case, more than 50 per cent of the bark circumference has been damaged or the leaf canopy has yellowed, such trees should not be treated, as they do not recover. These trees need to be uprooted and pest stages in those trees should be destroyed. The timber of such uprooted trees should be shifted out of the plantation and can be used as firewood.

How do we prevent the spread of pest infestation?

Two aspects are to be borne in mind to prevent spread of pest infestation;

i) reduction of pest population in a given location and
ii) rescuing the trees in initial stages of infestation.

To achieve these aspects, the CSRB infested trees should be identified in the initial stages of infestation during the nut collection period and marked suitably. Treatment of all such initially infested trees should be done AT A TIME and if possible on a community basis following the method mentioned above. Also, the trees which have yellowing of the canopy and / or have more than 50 per cent of the bark circumference damaged should be uprooted and pest stages in the root zone should be destroyed. This approach is called "PHYTOSANITATION" which helps to reduce the pest population in a given location and leads to lesser fresh incidence of the pest in the subsequent years. Extensive field trials have shown that on adopting this phytosanitary measure, a reduction in the number of freshly infested trees and also a significant reduction in the number of larvae occurring per infested tree could be achieved.

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TEA MOSQUITO BUG AND ITS MANAGEMENT

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Introduction

Tea Mosquito Bug (TMB) *Helopeltis* spp. is one of the major pests of cashew. Both nymphs and adults feed by sucking the plant parts, injecting poly-phenoloxydase(toxins) from their salivary glands. Typical feeding damage by *Helopeltis* spp. appears as a discoloured necrotic area or a lesion around the point of entry of the mouth parts inside the plant tissue. The infestation of inflorescence results in "blossom blight". Three species of TMB, *Helopeltis antonii* Signoret, *Helopeltis bradyi* Waterhouse and *Helopeltis theivora* Waterhouse are found in India. Among them, *H. antonii* is the dominant species. Each insect can damage 3-4 shoots or panicles leading to heavy loss in yield. Under outbreak situations, a damage of 25-30 per cent may be expected.

Biology

The adult bugs are slender, elongate, 6 to 8 mm long, reddish brown in colour with a black head, red thorax and black and white abdomen. Colour variation among the adults has been reported. A pin like, knobbed scutellar process occurs dorsally in both the nymphs and adults except in the first instar nymphs.

The pre-oviposition and oviposition periods ranged from 3 to 5 days and 5 to 10 days, respectively. More than 75 per cent of the eggs are deposited during the first half of oviposition period. The presence of sex pheromone in females of TMB has been demonstrated.

The eggs are inserted into tender shoots, stalk of inflorescence and on the leaf midrib and petioles, either singly or in groups of 2 to 6. The presence of a pair of minute silvery hair like unequal chorionic processes indicates the presence of an egg. The five nymphal instars are completed in 8 to 13 days. Adults live for about 5 to 18 days and the total life cycle is 20 days. A mass culture technique for TMB has been standardised using cashew shoot as a host material.

Host range

The nymphs and adults of TMB feed on a wide variety of crop plants such as eucalyptus, mahogany, neem, cocoa, cinchona, guava, drumstick, black pepper, Singapore cherry, cotton, *Lawsonia inermis* (mehendi) and allspice. During off season, the activity is mainly confined to these hosts and the pest migrates to cashew during flushing, flowering and fruiting period of cashew. Cashew is the most preferred host for TMB during the cropping season.

Distribution

The pest is distributed in most of the cashew growing regions of Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu, Andhra Pradesh, Gujarat, Chhattisgarh and Orissa. Neem is the primary host of *H.antonii* especially in Tamil Nadu and southern parts of Karnataka and Andhra Pradesh. The pest spreads to cashew from neem in these areas, whereas in Maharashtra, Gujarat and Chhattisgarh it is confined mainly to cashew. Apart from *H.antonii , H. theivora* Waterhouse, *H.bradyi* Waterhouse and *Pachypeltis mesarum* Kirkaldy are also causing similar damage to cashew in certain areas.

Nature of damage

Both nymphs and adults suck the sap from tender leaves, shoots, panicles and immature nuts and apples. The injury due to insertion of stylets by the insect induces exudation of resinous gummy substance. TMB also releases certain toxic secretion into cashew. All these activities of the insect lead to the typical formation of necrotic lesion symptoms around the point of stylet insertion by the bug. The lesions on shoots coalesce and ultimately result in drying of shoots/ shoot blight.

The infestation of inflorescence or panicles results in blossom blight. In certain endemic areas, most of the flushes dry up and the tree presents a scorched appearance. The immature nuts infested by TMB shrivel and dry up, while older nuts and apples develop a scabby appearance. Each insect can damage 3-4 shoots or panicles during its life cycle thereby, leading to heavy loss in nut yield.

Seasonal abundance

The build up of the pest commences during October - November synchronizing with the emergence of new flushes, after the cessation of the monsoon. The population reaches a peak during January, when the trees are in full bloom. The activity of the pest in cashew is seen till May. The activity is minimum during the monsoon period (June - September). In young plantations, the pest is noticed continuously with a higher intensity during February and March.

Incidence of disease

The fungal pathogens, viz., *Gloeosporium mangiferae* and *Phomopsis anacardii* have been reported to cause blossom blight in association with TMB. The feeding injury by the bug is one of pre-disposing factors for the infection and expression of die-back disease caused by *Colletotrichum gloeosporoides* and *Botryodiplodia theobromae*. When the dried shoot is split open, discolouration may be seen in softwood region indicating the manifestation of the fungal disease. A loss of 25 to 50 per cent nut in nut in yield has been reported from Karnataka, Maharashtra, Goa, Kerala and West Bengal due to combined effect of TMB and disease incidence.

Natural enemies

A total of four endo- parasitoids have been recorded parasitizing eggs of TMB in west coast regions of the country. They are *Erythmelus helopeltidis* Gahan. (Mymaridae) *Telenomus* sp. (Laricis group) (Scelionidae) and *Chaetostricha* sp. (Trichogrammatidae) and *Gonatocerus* sp. nr. *bialbifuniculatus* Subba Rao. In the east coast , *Ufens* sp. is the only egg endo- parasitoid observed on TMB. However, the attempts to multiply these endo-parasitoids under laboratory conditions was not successful, as these require live TMB eggs for the development.

Several species of spiders, *Hyllus* sp., *Oxyopes sehireta*, *Phidippus patch* and *Matidia* sp. have been observed predating on TMB . Five species of reduviid bugs (*Sycanus collaris* (Fab), *Sphedanolestes signatus* Dist. and *Endochus inornatus* Stal., *Irantha armipes* Stal. and *Occamus typicus* Dist. have also been recorded as predators. Ants of the species *Crematogaster wroughtonii* Forel (Formicidae) and *Oecophylla smaragadina* Fabricius predate on nymphs of the pest. *Aspergillus flavus* and *A.tamarii* are reported as entomopathogens on TMB.

Reactions of cashew types

Though all the germplasm accessions and related varieties are potentially susceptible to this pest, “Bhaskara”, a variety developed at Directorate of Cashew Research, Puttur escapes TMB damage due to non-overlapping of the cropping period with that of peak pest population. This variety was developed from a tree of seedling origin identified during 1982 from severely of TMB infested location, situated at Forest Department Cashew Plantation, Gaodengrem, Canacona Taluk, South Goa. This variety has midseason flowering habit which aids in escaping from the attack of TMB under low to moderate outbreak situation. In case of pest damage on first batch of panicles due to TMB, subsequently the trees of this variety flower again enhancing the possibility good yield during the same season.

Chemical control

Proper surveillance for pest damage symptoms during flushing, flowering and fruiting period is essential for the management of this pest. Whenever the incidence of pest is noticed on 5-10 per cent of the flushes, the first round of pesticidal spray should be given. The second round of spray should be invariably completed within 3-4 weeks time if the TMB population still persists. If panicle damage is severe (beyond 50%) because of delayed insecticidal application, further sprays will not result in improved yields. Hence, it is absolutely necessary to keep a constant vigil on the build up of the pest especially during first month of flushing and to initiate timely insecticidal control. However, a two spray schedule(need based) is being presently recommended instead of routine/earlier recommended three spray schedule. The third spray needs to be taken up only based on necessity i.e., in case pest population persists even after the second spray.

The present recommendation for chemical management of tea mosquito bug is as follows:

First spray	:	Monocrotophos(0.05%) or Profenophos (0.005%) - at flushing stage
Second spray	:	λ-cyhalothrin (0.003%) or triozophos (0.05%) - at flowering stage.
Third spray(if pest persists)	:	λ-cyhalothrin (0.003%) - at fruit set stage

Though cashew is an insect pollinated crop, use of λ-cyhalothrin (0.003%) during the flowering stage did not affect the fruit set. Among the different insecticides, λ-cyhalothrin (0.003%) has higher benefit cost ratio (4.5).

Whenever die- back disease is noticed, the affected shoots and branches below the site of infection should be pruned and destroyed. The cut surface should be protected with Bordeaux paste (10%). Spraying the canopy with Bordeaux mixture (1%) may be followed after this process.

General precautions for insecticidal application:

- Chemical should be mixed properly and filtered before filling the sprayer.
- Spraying should be done in the early hours of the day (7-11 AM) or in the evening (3-6 PM).
- Spraying should be taken up immediately when initial symptoms of TMB damage are noticed first.
- If it rains immediately after spraying, the spraying has to be repeated.
- Entire canopy area should be sprayed with chemical. Approximately, 6-8 litres of solution is required for a tree of 15 -20 years depending upon the canopy.
- Same insecticide should not be used repeatedly. It is better to alternate equally effective insecticide for each spray.
- Empty chemical container should be destroyed by puncturing / cutting into pieces and buried into the soil.
- Drinking water source should not be contaminated while spraying.
- Cloth mask covering nose and mouth should be invariably used by the person who attends to spraying.

MANAGEMENT OF MINOR PESTS OF CASHEW

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In India, cashew is reported to be infested by more than 180 pests at different growth and development stages. Apart from TMB and CRSB, there are also few other pests that cause considerable damage and yield loss. All parts of the plant *viz*., leaf, stem, bark, root, flower, apple and nut are fed upon by at least one pest species, resulting in 11 - 55 per cent loss in yield, if left unchecked. However, depending on the climate, location and age of the plantation, each geographic region has its own distinctive pest complex. Few important minor pests of cashew and their management aspects are described here under.

1. Shoot tip caterpillars

Pale yellowish green young caterpillars of *Anarsia epotias* Meyr damage shoot tips of cashew by webbing together the tender leaves and feed within it at the early stage. Later on, they bore in to the terminal shoots and tunnel inside up to 2-3 cm. A gummy substance oozes out from the infected tips and finally the attacked shoots dry up. Egg, larval and pupal period lasts for 3-4 days, 12-16 days and 7-10 days respectively. Similarly, the tiny, yellowish to greenish-brown larvae of *H. haligramma* also damage shoot tips by folding the fresh leaves and feed within. Tender shoot tips are bored occasionally up to 25-35 mm, leading to drying-up of shoot tips. Terminal shoots turn black and perish, which results in production of auxiliary shoots. Larvae may also damage inflorescences subsequently. This pest is regularly reported from the east coast tracts.

2. Leaf miner

Leaf miner *Acrocercops syngramma* M. is one of the important pests of cashew during post monsoon period all over the country. The mining injury by caterpillars occurs both in the tender leaves as well as tender shoots and young plants are more prone to attack. Caterpillars mine and feed below the epidermal layer of the tender leaves causing extensive leaf blisters which later dry up causing distortion, browning and curling of the leaves. As the attacked leaf ages, the holes develop due to drying out of the damaged portion. Generally 1-6 caterpillars damage a leaf. During the developmental period they are dull white in colour and turn pinkish before pupation. After full development, larvae fall off to the soil where they pupate and emerge after 7-9 days as a silvery grey moth.

3. Leaf folder and leaf rollers

Larvae of *Anigraea albomaculata* damage tender leaves by making spindle shaped folds. Two to four terminal leaves are folded longitudinally one above the other and fastened with silken threads to form a tight tubular roll at the growing point. Light yellowish larvae of *Caloptilia tiselaea* M. cause damage by folding leaves terminally. While, larvae of *Macalla albifusa* Hamps. join the leaves one above the other by silken

threads and feed on them. Larvae are very active and wriggle out when disturbed and the damaged portion dries up gradually. In few places, larvae of *Sylepta auranticollis* Fabricius during their early stages roll the tender leaves and scrape the green matter, later they defoliate the entire leaves.

4. Other defoliators

Caterpillars of *Orthaga exvinacea* Hampson web together tender shoots and leaves live within the webs and feed on the leaves. Presence of silken webs reinforced with pieces of plant parts on terminal portions and blossoms as well as dried up appearance are the symptoms of its infestation. Among the vast number of hairy caterpillars two species *viz*., *Metanastria hyrtaca* Cram and *Lymantria ampla* Wlk cause severe sporadic defoliation in cashew. Similarly, geometrid loopers like *Oenospila flavifusata* Walker, *Thallasodes quadraria*, *Hyposidra talaca* (Walker) and *Pingasa ruginaria* Guenee cause defoliation. Damage by foliage thrips *viz*., *Selenothrips rubrocinctus* Giard, *Rhipiphorothrips cruentatus* Hood and *Retithrips syriacus* causes crinkling, roughening and shedding of leaves. The chrysomelid beetle, *Monolepta longitarsus* Jal. appear abundantly just after onset on SW monsoon and skeletonise the young leaves and tender shoots that finally dry off.

5. Stem and bark feeders

Caterpillars of *Inderbela tetraonis* Moore make a small residential hole on the wood normally where the branches fork and from there make superficial galleries inside which they feed on the tissues. Presence of winding galleries on the bark made of powdered bark, faecal pellets and silk webbed together indicates this pest attack. Feeding damage of cambial tissues of small branches by this larva results in drying up of those branches. The eggs are laid under loose bark and larvae are pale brown with dark head move along the branches concealed under the gallery. Larval period lasts even up to 10-11 months while, pupal period lasts 15-25 days.

6. Leaf and blossom webber

Cashew shoots bearing fresh flushes and flowers are attacked by leaf and blossom webbing caterpillar, *Lamida* (*Macalla*) *moncusalis* Wlk. especially in east coast tracts of India. Symptoms of infestation are presence of webbing on terminal portions, with clumped appearance, and drying of webbed shoot/ inflorescences. Galleries of silken webs reinforced with plant scraps and castings, indicate the presence of caterpillars.

7. Apple and nut borer

Larvae of *Thylacoptila paurosema* attack tender apples and nuts. Dark pink larvae initially damage flowers by webbing the panicles and feed the unopened flower buds. Then they bore inside the tender nuts and developing apples resulting in shrivelling and premature fall. In the developed green nuts and apples, larvae tunnel near the

junction of apple and nut and the boreholes are plugged with frass and excreta. The caterpillars of *Hyalospila leuconeurella* bore through the apple from one end to the other and remain inside the apple till the fruit drops. Attacked apples generally fall down from the trees. Nuts when attacked become severely deformed. Similarly, *Nephopteryx* sp. (Pyralidae: Lepidoptera) is common in Tamil Nadu and Andhra Pradesh attacking fruits at all stages of development causing up to 60 per cent of nut damage. The larvae scrape the epidermis of tender nuts and apples and move to the point of attachment of nut and apple. The entry hole is minute and plugged with the excreta. The infestation spoils the apples and nuts, larvae also feed on the kernel.

8. Hemipteran pests of apple and nuts

Apart from TMB, aphids (*Toxoptera odinae* van der Goot), many species of thrips and mealy bugs (*Planococcus citrii* Risso, *Planococcus lilacinus* Cockrell and *Ferrisia virgata* Cockrell) also damage immature apples and nuts by sucking their sap. Occasionally, the pentatomid bug, *Catacanthus incarnatus* Drury also damages young cashew apples.

Management of insect pests of cashew

- Proper surveillance and regular monitoring of the pest situation has become essential to rationalize their management strategies so as to avoid the need for blanket insecticidal sprays. Removal of weeds in cashew plantations should be taken care, because, weeds especially *Terminalia paniculata*, *Chromolaena odorata* are not only competitors of cashew but also serve as host plants for many of the cashew pests.

- In young cashew plants, wherever possible, removal of different stages of pests like egg laden leaves or shoots, caterpillars, pupa or cocoons, grubs from the infested plants gradually reduces the pest population. Removal and destruction of mealy bug and aphid infested plant parts helps to minimize their infestation and spread.

- Under unsprayed conditions, an array of predators *viz*., spiders, ants, reduviids, coccinellids, neuropterans, hemipteran bugs and praying mantises take care of many of the cashew pests. Red ants (*Oecophylla smaragdina*) are the potential biocontrol agents in cashew plantations that feed on bugs, caterpillars, hoppers, moths etc. Red ant colonized old cashew trees are generally free from pests. Apart from predators, there are also parasitoids that take care of several cashew pests. Hence, indiscriminate spraying may be avoided. Trees harbouring ant nests especially red ants should be spared of spraying to allow them to take care of pests naturally.

- Botanical insecticides like Neem (*Azhadirachta indica*) oil @ 3-5%, Karanj (*Pongamia pinnata*) oil @ 2%, Fish Oil Rosin Soap and neem seed kernel extract @ 1% are some of the botanical preparations effective against many of the foliage pests of cashew like leaf miners and leaf feeding caterpillars.

- Generally, chemical sprays taken up against tea mosquito bug usually take care of the infestation of most of foliage pests, hence spraying for other pests is required only

under severe infestation. Insecticides recommended for cashew pest management include, monocrotophos 36 SL, quinolphos 20 EC, carbaryl 50 WP, lambda-cyhalothrin 5 EC, chlorpyriphos 20 EC, triazophos 40 EC, profenophos 50EC, phosphamidon 40 SL, phosalone 35 EC and dimethoate 30 EC.

- Rotation of insecticides between sprays is advised to prevent development of resistance to any particular pesticide. Avoiding spraying of carbaryl and phosphomidon at the time of flowering has to be taken care, as these are highly toxic to honey bees. Spraying should be taken up before 9 am or after 4 pm in order to save cashew pollinators.

CASHEW NUT PROCESSING

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The economic interest has made many countries of the world to encourage the cultivation of cashew and it is fast becoming an export produce in many developing countries. Among horticultural crops, cashew has been known to provide very high economic returns. The raw cashew are either exported or processed prior to export. The cashew kernel is the main product which has aroused economic interest in the wide spread cultivation of cashew. The kernel is widely consumed as snacks and used as a basic ingredient for confectionaries in most countries of the world because of its good nutritive value. Primarily raw nuts, cashew kernels and cashew nut shell liquid (CNSL) are the three main cashew products which are traded in the international market. The importance of cashew (*Anacardium occidentale* L.) for the Indian economy has been due to its role as an earner of foreign exchange and also to its employment generating capacity in the processing sector. Cashew processing in India started as a small cottage industry and has developed into a highly organized labour intensive industry and gradually progressing towards mechanization. Since the world demand for cashew kernels has been rising steadily for several years in the past conferring significant price increase, the processing of cashew remains still a highly profitable industry.

Cashewnut processing industries:

India is the largest producer, processor and exporter of cashew in the world. There are about 3750 cashew processing factories employing more than 10 lakh personnel with an estimated processing capacity of 20 lakh TPA. Export of cashew kernel in the year 2012-13 was around 1.01 lakh MT valued Rs 5063 Crores. Cashew industries have a simple organizational structure and mostly under private management i.e. proprietorship (63%) or partnership (19%). Since it requires large amount of capital investment and working capital, most of the industries depends on commercial banks and state financial agencies. About 62% of the industries are categorized under "Manufacturer exporter". This is primarily due to encouraging export policy and higher exchange value for USD. Tiny processing units i.e. up to 100 TPA and medium capacity processing industries i.e. 100-500 TPA accounts for 39% and 42% respectively, due to raw nut shortage and financial constraints. In order to run the factory through out the year, 50% of the factories import raw nut during off-season from African countries. About 8.21 lakh MT raw nuts were imported during 2012-13.

Most of the industries utilized capacity is below 50%. About 90-95% of women force is employed in these industries at different stages of operation. Total employees strength varied between 50 and 400. Men labourers are involved in drying, stacking, roasting, kernel drying and packing. The State Government fixes labour wages and it differs from state to state.

Raw cashew nut:

Raw cashew nut is kidney shaped one with approximately 3.5mm thick leathery outer skin (Epicarp) and thin hard inner skin (Endocarp). Between these two walls of the shell is a honeycomb structure, which contains the phenolic material, commercially, known as cashew nut shell liquid (CNSL). The kernel is inside the shell wrapped in a thin brown skin known as testa.

Raw nut procurement:

Cashew nut is a seasonal crop, harvesting of nuts in India starts from March to June. It has been found that the processors obtain raw material in four ways. I) Directly from producers; ii) Direct purchase from local market; iii) Through commission agents and iv) Through imports. While procuring the nuts, normally 3 tests are conducted.

Visual test:

Size and colour of the nuts to check the maturity.

Floating test:
About 1 kg of sample is transferred to a vessel containing water. After continuous stirring floaters are collected and counted. Mostly immature nuts, due to its lower density than water, improperly filled nuts and deteriorated nuts floats. Based on the percentage of floaters the raw nut quality is assessed.

Cutting test:

Raw cashew nut sample of 1 kg is collected from different bags and mixed together. 1 kg raw nut is taken from diagonal samples and cut open using hand cutting tool. Based on the kernel appearance i.e. white, shriveled, black spotted or rejects, the percentage of good kernel is calculated. This is considered for valuating price of fixing the price.

Cashew nut processing:

It can be defined as the recovery of edible kernel from raw nut by manual or mechanical means. In India, the processing is mostly manual and it consists of moisture conditioning, roasting, shelling, kernel drying, peeling, grading and packing. Cashew shell is pliable and unsuitable for any type of manual or mechanical opening in its natural state. Conditioning or

roasting, however, will harden and make cashewnuts brittle, susceptible for cracking or splitting. Various conditioning methods followed India are: (i) Open pan roasting; (ii) Drum roasting; (iii) Oil bath roasting and (iv) Steam boiling.

- **Drum roasting:**
  In this process the nuts are fed into an inclined rotating drum which is heated initially to such an extent that the exuding oil ignites and burns, thus charring the shell. The drum maintains its temperature because of the burning cashewnut shell liquid (CNSL) oozing out of the nuts. Roasting generally takes about 3-5 minutes and the drum is rotated by hand during this period. The roasted nuts, which are still burning, are covered with ash to absorb the oil on the surface. The shell becomes brittle and rate of shelling and the outturn of whole kernels reported to be highest among the three methods of roasting.

- **Oil bath roasting:**
  Though it is an outdated method in India, majority of Brazil and African countries still follows this system. The roasting equipment consists of a rectangular vessel, 2-3 feet wide and 3 feet deep, with a flat bottom. The whole assembly is embedded in brickwork furnace which uses spent cashew shell as fuel. In this method, raw nuts are passed through a bath of heated CNSL maintained at a temperature of approximately 190-200°C by means of screw or belt conveyor for 1-3 minutes.

- **Steam boiling:** This method is adopted in the factories where hand and leg operated shelling machines are used. The nuts after conditioning are given a mild roasting in an equipment for 20-25 minutes at 5.6-7.0 kg cm^{-2} . This process helps to loosen the kernel and make its removal easy.

Shelling:

- **Manual:**
  Nuts after roasting are shelled (decortication) manually in most of the units in Kerala and Tamil Nadu. Manual shelling is an operation requiring some amount of dexterity. Nuts are knocked 2-3 times on each of the long edge of a wooden mallet or light hammers taking care to see that the whole kernels are released without damage or breakage as far as possible. The outturn will be 90 % of whole kernels. Individual workers' output is about 15-20 kg per 8 h of working day. Workers smear ash or clay on their hands to avoid contact of corrosive shell oil with the skin.

- **Mechanical:**
  The mechanical shelling gadget consists of two blades, between which the raw nut is inserted. The gap is adjustable and therefore it will be advantageous if the raw nuts are pre-graded on the basis of size. By means of lever operated by leg, the blades

are brought together which will cut the shell without damaging the kernel inside. The nut is cut to the depth of the shell and a hand lever is pressed to open the shell into two parts. The pressure exerted by the foot and hands should be so regulated as to cut only the shell and not the kernel. The kernel is then scooped out by means of sharp needle. The output per worker per 8 hours shift in this method is estimated to be 14-22 kg of kernel. The main disadvantage of this method is while handling the mild roasted kernels the CNSL oil may contaminate it, and varying size of the nuts requires careful manipulation during cutting to avoid injury to the hands.

Kernel Drying:

The kernels after separation from the shells are dried to reduce the moisture and loosen the adhering testa. The most commonly used drier is 'Borma dryer'. Kernels are placed in trays with wire mesh bottom and loaded into metal chambers. Indirect hot air from furnace and blower assembly helps to dry out the kernel moisture. Spent shells from the decortication process are burnt as a source of heat and air temperature ranging from 70-100°C will be prevailing inside the whole chamber. In order to get uniform drying, the position of trays is changed at intervals of 30 min. The normal duration of heating is 8-10 h. The moisture content of the dried samples will be in the range of 2-4 per cent (db).

Peeling:

Peeling is the operation of removal of the testa from the kernels. As the kernels are quite brittle after removal from the dryer they have to be cooled for 24-48 h for moisture absorption. A slight pressure applied through the fingers separates the testa. Sharp bamboo sticks or SS blades are also used to remove the adhering testa. The average peeling capacity is 7-10 kg/head /day.

Grading and conditioning:

Kernels are graded on the basis of specification prescribed by Govt. of India under the export (quality control and inspection) Act 1963, which recognizes 23 different export grades of kernels. The kernels are conditioned before packing in sealed tins. If the kernels are too dried at the time of packing, they are liable to breakage during transport by land and sea. If the moisture exceeds limit of 5 per cent kernels become susceptible to microbial and oxidative spoilage.

Packaging of kernels:

Cashewnuts are subjected to rancidity and very quickly go stale. Therefore packing should have low permeability of oxygen and moisture. Method of packing should involve either vacuum or inert gas inside the packing. At present the bulk of cashewnuts is packed in tin containers weighing 25 lbs. Tins kept on vibrating platforms are filled with kernels through a chute. After filling and weighing the tins are evacuated filled with CO_2 with the help of "VITAPACK" machine and sealed. Introduction of alternative method of flexible packaging (Mould Vacuum Packaging) with nitrogen as inert gas is gradually gaining importance. After securing ISO 9000 and introducing HACCP (Hazard analysis and critical control points), importing countries are following stringent quality standards for cashew kernels and the present system of tin packaging is bulky and difficult to dispose off these tin containers.

CASHEW APPLE PROCESSING

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Introduction

Cashew, a native of Brazil has become one of the most important commercial crops of India. The crop is grown for its nut, which is considered as the only economic produce from the crop India, have clearly revealed that the cashew apple, weighing about 8-10 times that of the nut, is an equally valuable produce from the crop, if it is economically exploited. The production of cashew apple in India is estimated to be around 5 to 6 million tonnes per annum, which is almost completely wasted, except in Goa where it is used for the preparation of cashew Feni. Cashew apple is highly nutritious and comparable with many other tropical fruits.

The Cashew Apple

The cashew apple is the pseudo fruit, attached to the nut which develops from the pedicel. The cashew apple is a soft fruit, rich in nutrients and contains five times more vitamin C than an orange. The ripe apple is very juicy, spongy, somewhat fibrous, having a unique smell and has a very thin skin that gets easily bruised. The astringent and acid principles in cashew apple produce a rough, unpleasant and biting sensation on the tongue and throat, which is a major drawback of the fruit. The astringency of cashew apple is determined to a large extent by the tannin content, a phenolic compound, and its content varies from 0.06 to 0.76 g per 100 g. The astringency is sometimes removed by steaming the fruit for five minutes before washing it in cold water alternatively boiling the fruit in salt water for five minutes or soaking it in gelatin solution also reduces the astringency.

Cashew apple is highly nutritious and is a valuable source of sugars, minerals and vitamins especially vitamin C and riboflavin. The chemical composition of cashew apple is: Moisture 87.8%, protein 0.2%, fat 0.1%, carbohydrate 11.6%, crude fibre 0.9%, calcium 10.0 mg/100 g, phosphorous 10.0 mg/100 g, iron 0.2 mg/100 g, vit C 261.0 mg/100 g, minerals 200.0 mg/100 g, thiamin 0.02 mg/100 g, riboflavin 0.5 mg/100 g, nicotinic acid 0.4 mg/100 g and vitamin A 39.0 IU. The pH of the apples varies between 4.1 and 4.7 and total sugars from 6.7 to 10.5%. Ripe apples contain 0.76 to 1.17% pectin.

Consumption of cashew apple/ products

Cashew apple is eaten fresh or cooked in curries or fermented into vinegar or as an alcoholic drink. It is also used to make preserves, chutneys and jams in some countries such as India and Brazil. In many countries, particularly in South America, the cashew apple is used to flavor drinks, both alcoholic and nonalcoholic. In Brazil, it is a popular fruit flavor for the national drink, the caipirinha. In fact, in many South American countries, the cashew apple is more popular as a food than the cashew nut. Cashew apples are extremely soft and easily bruised because of which cashew juice and cashew juice concentrate are often shipped to the non producing countries instead of the fresh fruit.

Uses of cashew apple

Traditionally, several products are prepared from cashew apple, including those with medicinal properties, some of which are still used.

The major uses of cashew apple are presented below:-

I. Direct consumption

Cashew apple is widely eaten raw as fresh fruit. Either whole apples are consumed or they are cut into small pieces, mixed with table salt and eaten. Quality for fresh consumption is related to low astringency and acidity, sweetness, firmness, size and pear shape.

II. Manufacturing of food products

Ripened cashew apples are used for the preparation of many food products. Good quality pulpy apples will be selected without any bruises and damages and cleaned by washing thoroughly in water. Plastic buckets and barrels are to be used for dipping in water and further cleaning. Juice can be extracted in expeller, screw press or hydraulic press. Tannin has to be removed from the juice/cashew apple before the preparation of any product and then they can be stored.

1. Beverages

a. Fresh apple beverages

Clarified and cloudy juice, juice concentrate, syrup, squash and ready- to- serve are some of the nutritious and refreshing beverages ,that can be made from the unfermented juice of cashew apple by adding varying concentrations of sugar, citric acid and preservative. and carbonated drink.

b. Fermented beverages

Cashew apple can be utilized for the manufacture of the fermented products like wine, vinegar, liquor and alcohol. Cashew apple vinegar can be prepared by alcoholic andsubsequent acetic fermentation of juice and wine is prepared by the fermentation of cashew apple juice by yeast.

2. Products from cashew apple pulp

Jam is the most important pulp product of cashew. It can be prepared by boiling the cashew fruit pulp with a sufficient quantity of sugar and a pinch of citric acid to a reasonably thick consistency, firm enough to hold fruit tissues in position. Mixed fruit jam can also be prepared by mixing cashew apple pulp with equal quantity of banana pulp or pineapple pulp. Cashew bar is prepared from the pulp by adding 40% sugar. Halva is made from cashew apple pulp by adding coconut milk, sugar and ghee.

3. Confectionery products

Candied fruit is prepared from cashew apple by impregnating with cane sugar with subsequent draining and drying. One kilogram of cashew apple on processing gives 745 g candies. Cashew apple can also be utilized for the preparation of tutty fruity. One kg of cashew apple on processing gives 715 g tutty fruity. Cashew apple powder is used to make chocolate, biscuit, pudding, etc by adding sugar, milk powder and ghee in various quantities.

4. Culinary products

Sliced raw green fruit can be used to prepare pickle using chilli powder, gingelly oil, fenugreek powder, asafoetida, turmeric powder, garlic, mustard powder, a pinch of sodium benzoate and salt to taste. Chutney can be prepared from sliced cashew apple using sugar, onion, ginger, spices like cumin seed, pepper, cardamom, cinnamon and coriander powder, salt and vinegar.

IV. Neutraceutical products

Ascorbic acid, fibre, carotenoid pigments, minerals which are of significance to human health are contained in cashew apple. Cashew apple powder lipids are rich in unsaturated fatty acids. A valuable by- product obtained from cashew apple waste, pectin is used in manufacturing jams, jellies, etc. and is useful in pharmaceutical preparations, cosmetics etc.

V. Agricultural uses

Cashew apple residue can be used for vermicompost production and as animal feed. It is observed that cashew apple extraction is an effective insecticide against red palm weevil in coconut. Cashew apple and gum extract, in combined form or alone, acts as an effective repellent against leaf feeding pests of vegetables. The cashew apple is dried and powdered into meal which can be used as bait for catching crustaceans.

VI. Energy production and industrial uses

There is a high potential to utilize cashew apple for the production of bio- fuel and biogas. Food Products from Cashew Apple Preliminary Processing: The presence of astringent and acrid principles producing an unpleasant and biting sensation on the tongue and throat and poor storability are the two major constraints in the economic utilization of cashew apple.

a. Clarification and storage of juice:

The extracted juice is strained through a muslin cloth and kept for clarification. Powdered and cooked sago @ 5 g/litre of juice is added for clarification. Then potassium Meta bisulphite (KMS) 2.5 g and citric acid 5g are added to every liter

of the juice. Stirred well kept for 12 hours to allow the tannin to settle and the upper layer of clear juice is decanted carefully without mixing the sediments. This clarified juice is stored in well sterilized air tight plastic barrels which could be used for off season product preparation.

B. Detanning and storage of cashew apple:

The cleaned apples are dipped in 5% salt solution for three days, changing water every day. Fourth day the fruits are taken out and washed thoroughly in fresh water. They are steamed in pressure cooker for 10 -15 minutes, made into pulp and stored in air tight glass bottles after adding 2.5 g KMS and 5 g citric acid for every kilogram of pulp. Green cashew apples are detanned in the same way by dipping in 8% salt solution and then used for pickle preparation

Value Added Products from Cashew Apple

1. Cashew apple syrup:

The clarified juice is siphoned out as the raw material for the preparation of syrup. Sugar citric acid and lemon yellow colour are added to the clarified juice in required quantity to produce syrup. Taste is better if served chilled. Syrup has a storage life of one year. Cashew apple syrup contains 276 mg Vitamin C and drink contains 140 mg vitamin C/ 100 g. Syrup has a storage life of one year.

2. Cashew apple drink:

The drink is an RTS (Ready - To - Serve) beverage. It is prepared by adding water and sugar to the required quantity of clarified juice. Drink is marketed both in glass bottles and in attractive food rade pouches. Pasteurized drink in glass bottles has a storage life of three months nder ambient storage conditions.

3. Cashew apple carbonated drink:

Cashew apple carbonated drink (soda) is made by adding chilled carbonated water at 100 psi pressure to the required quantity of syrup.

4. Cashew Apple- Mango Mixed Jam:

The ripe apples are selected, cleaned and soaked in salt solution for three days to remove tannin. Apples are again washed in water, cooked, made into pulp and is mixed with equal quantity of mango pulp. Pulp is mixed with sugar and citric acid to prepare jam. It is marketed under the trade name Cashewman Mixed Jam. Vitamin C content of the product is 18 g/100g.

5. Cashew apple candy:

It is a sweet product and quality apples with good shape are selected for candy preparation. As in jam preparation, tannin is removed from apples, cooked, pierced using fork and dipped in sugar solution. Concentration of sugar solution is gradually increased so as to reach 700 brix. After two weeks of soaking, sugar solution is drained out and candy is dried in shade. It takes about 2-3 weeks for making the final product. Vitamin C content of the product is 28.4 ,mg/100g.

6. Cashew apple pickle:

Mature but unripe cashew apples are collected directly from plantations carefully without disturbing the flowers and tender nuts. After cleaning, the fruits are cut into small pieces and astringency is removed by immersing in salt water. After removing from salt water, it is again washed and pickle is prepared using oil, chili powder, fenugreek powder, turmeric powder, ginger and garlic paste.

7. Cashew apple vinegar:

Vinegar is prepared from cashew apple juice by adding a little sugar and yeast to cashew apple juice and keeping for one week for alcoholic fermentation. After one week alcoholic ferment is got to which three times mother vinegar is added and again kept for 2 weeks. After this period the vinegar is ready with the acidity of 4 – 5 %.

8. Cashew apple chocolate:

Cashew apple powder is used to make chocolate by adding sugar, milk powder and ghee in appropriate proportions.

9. Cashew apple biscuit:

Cashew apple biscuit is prepared using cashew apple powder, ghee, sugar and maida in required quantities and further baking.

10. Cashew apple wine:

Wine is a fermented product from cashew apple. This is made by mixing cashew apple, sugar; a little clove and luke warm water after adding starter solution. Starter solution is prepared by adding 5g of yeast to 10g sugar and keeping for half an hour. The mixture should be kept in glass bottles or clay pots for 21 days with daily shaking. Then strained the solution and again kept for 21 days by which time the wine is ready.

11. Cashew apple squash:

For making cashew apple squash, sugar and citric acid are added to water and boiled. The flame is switched off and then clarified juice is added, cooled, a pinch of color is added, strained, bottled and sealed. This can be diluted to three times for drinking.

12. Cashew apple bar:

Cashew apple bar is prepared from the pulp y adding 40% sugar.

13. Cashew apple halva:

Halva is made from cashew apple pulp by adding coconut milk, sugar and ghee.

14. Cashew apple pudding:

Cashew apple pudding is another confectionery which is prepared by mixing cashew apple powder, sugar, milk and gelatin along with, vanilla essence.

REFERENCE:

Most of the information given above is made available from article published by Sobhana, A. and Jose Mathew in *Cashew Week*, October 2012, Vol.13, Issue 40, pp 84-92.

APPROACHES FOR TRANSFER OF CASHEW PRODUCTION TECHNOLOGIES

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Introduction

Agricultural extension in India is largely deployed by government, implemented mainly through government institutions and to some extent through non-government agencies. In India, the extension efforts, particularly transfer of technology efforts, have largely been taken up by the state departments of agriculture and other disciplines as a state subject. The Indian Council of Agricultural Research (ICAR) as the apex body to provide new technologies in agriculture and allied aspects has its own transfer of technology activities. The extension efforts of ICAR, particularly through its institutes are largely of frontline extension programmes. Transfer of technology efforts in cashew by ICAR are also mostly frontline in nature while large scale field level extension work being taken up by line departments of various states. This chapter looks at the various approaches, models and methods used in transfer of technology in general and those which are utilized in cashew extension by DCR, Puttur.

1. Approaches for cashew extension

There are various approaches in agriculture extension. In general we have identified eight different approaches to extension work. These approaches are also applicable for cashew extension and are briefly summarized below.

1.1 The general agricultural extension approach

This approach assumes that technology and knowledge that are appropriate for farmers exist but are not being used by them. The purpose is to help farmers increase their production. The approach is usually fairly centralized and government-controlled. Planning is done on a national basis by the central government 'which knows better than farmers'. This is a typical case of top–down planning. Field personnel tend to be large in number and high in cost, with the central government bearing most of the cost. The rate of adoption of important recommendations and increases in national production are the measures of success. A survey of agricultural extension programs indicated that agricultural extension generally was part of the Ministry of Agriculture, with field extension officers at the bottom of the hierarchy and a minister at the top. This approach lacks two-way flow of information. It fails to adjust messages for each different locality. Only farmers who seek advice benefit and these tend to be large-scale wealthier farmers. This approach does provide farmers with information on a number of production alternatives from one single source.

1.2 The commodity specialized approach

The key characteristic of this approach groups all the functions for increased production—extension, research, input supply, marketing and prices—under one administration. Extension is fairly centralized and is oriented towards one commodity or crop and the agent has many functions. Planning is controlled by a commodity organization for the purpose of increasing production of a particular commodity. Highly trained scientific personnel equipped with expensive vehicles and field scientific apparatus are employed. Techniques recommended must produce financial benefits for farmers, and be demonstrable on farmers' own fields. New inputs must be accessible, a credit scheme established, and the ratio between farm-gate inputs and commodity prices considered. Technology tends to be appropriate and distributed in a timely manner because it focuses on a narrow range of technical concerns. Interests of farmers, however, may have less priority than those of commodity production organizations. Successful examples in India vary from Rubber board, Spices board and that of Coffee board but cashew extension is yet to be taken up in this approach.

1.3 The Training and Visit approach

Training and Visit (T&V) is one of the best known of the recent approaches, which was adapted by many countries to support the development of state extension services. It provides continuous feedback from farmers to extension agents and to research staff; it allows for continuous adjustment to the farmers' needs. The purpose of the training and visit approach (often called T&V) is to induce farmers to increase production of specified crops. This fairly centralized approach is based on a rigorously planned schedule of visits to farmers and training of agents and subject matter specialists. Close links are maintained between research and extension. Agents are only involved in technology transfer. Planning is controlled centrally and field personnel tend to be numerous and dependent on central resources. Success is measured in terms of production increases of the particular crops covered by the program. The T&V approach is again a top–down approach. The emphasis is on disseminating unsophisticated, low-cost improved practices, and teaching farmers to make best use of available resources. This builds on a combination of the individual and group approaches. In this system, the extension staff is trained every fortnight on relevant extension issues for that time of the year and the staff then extends these messages to contact farmers who receive special attention. Field days and other visits are arranged on the farms of contact farmers so that their neighbours can also benefit from the knowledge they have gained. Under T&V, the extension system changed its way of reaching out to farmers by using agents who focused mainly on technology diffusion. T&V extension agents would meet with a small group of 'contact' farmers who were expected to disseminate information to the members of their respective communities and convey farmer's opinions back to the agents, thus creating a feedback mechanism absent in the prior system. T&V did, however, have its critics. With continued budgetary crises of less developed countries, some argued that it was too expensive and impossible to implement over extensive regions. Highly dispersed farmers could never establish frequent contact with extension agents. And their needs varied widely and could not be addressed with a single, inflexible technology package.

1.4 The farming systems development approach

Farming systems research and extension evolved during 1965–80. This system was marked by greater emphasis on smallholder farmers and their livelihood systems, as researchers realized that such people were not being reached effectively with the traditional extension approaches. They thus began to use what is known as the farming systems approach to research and extension. This approach assumes that technology which fits the needs of farmers, particularly small-scale farmers, is not available and needs to be generated locally. A key characteristic of this type of extension is its systems or holistic approach at the local level. This approach is implemented through a partnership of research and extension personnel using a systems approach. Close ties with research are required and technology for local needs is developed locally through an iterative process involving local people. Analyses and field trials are carried out on farmers' fields and in homes. The measure of success is the extent to which farm people adopt technologies developed by the program and continue to use them over time. Control of the program is shared jointly by local farm families, extension officers, and researchers. Advantages of this system include strong linkages between extension and research personnel, and the commitment of farmers to using technologies they helped to develop. All on-farm trials (OFTs) conducted by Krishi Vigyan Kendras can be categorized under this approach. Cashew being a plantation crop, technology development process using this approach is fairly long. However the results from this approach are used widely for technology assessment and refinement and for providing micro-location specific recommendations.

1.5 The participatory agricultural extension approach

This approach assumes that cashew farmers are skilled in production from their crop, but their levels of living could be improved by additional knowledge. Active participation by cashew farmers themselves is necessary and produces a reinforcing effect in group learning and group action. Much of the work is through group meetings, demonstrations, individual and group travel, and local sharing of appropriate technologies. This approach often focuses on the expressed needs of farmers' groups and its goal is increased production and improved quality of rural life. Implementation is often decentralized and flexible. Success is measured through numbers of farmers actively participating, and the continuity of the program.

The participatory agricultural extension approach costs less, fits needs well, and is more efficient. However, it is more work for extension agents to organize and motivate farmers. It requires agents to live and to socialize with farmers. Where a government job is seen as a reward, the 'hardship' implied by this approach dooms it to failure. The agent is present only 'part time' and has no personal stake in the outcome. This explains why the approach is highly successful with cashew extension work done by various NGOs like BAIF, SKDRDP etc and not successful under government extension system.

Characteristics of the participatory cashew extension approach

Community-based extension and joint learning is central to this approach. The process emphasizes the participatory facilitation role of extension staff. Main characteristics of participatory cashew extension approach are that it integrates mobilization for planning and action with cashew development, agricultural extension and research; is based on an equal partnership between cashew farmers, researchers and extension; aims to strengthen cashew farmer's problem-solving, planning and management abilities; promotes cashew farmers' capacity to adopt and develop new and appropriate cashew production technologies; encourages cashew farmers to learn through experimentation, building on their own knowledge and practices; and recognizes that farming communities are not homogeneous but consist of various social groups with conflicts and differences in interests, power and capabilities.

The role of extension is to facilitate this process. Under the emerging model, good extension work means talking with farmers, working with farmers, learning from farmers and suggesting new approaches to farmers. A number of lessons have been developed based on past experiences. However, if one considers the FSA to technology development and transfer and participatory extension methods, the differences are not that significant.

1.6 The project approach

This approach concentrates efforts on a particular location, for a specific time period, often with outside resources. Part of its purpose is often to demonstrate techniques and methods that could be extended and sustained after the project period. It uses large infusions of outside resources for a few years to demonstrate the potential of new technologies. Control is at the central government level and there are often considerable financial and technical inputs from an international development agency. Short-term change is the measure of success. In the NAIP program of India, for example, financial support from the World Bank was used by the Ministry of Agriculture to support extension work in many different projects throughout the country. They were able to introduce innovations through an effort which combined the project approach with the specialized commodity approach. However this approach is rarely found utilized for cashew extension in India. One problem with this approach, however, is that a flow of ideas outside the project rarely occurs.

Integrated approaches aim at influencing the entire rural development process. Extension is only one though often crucial element in this strategy which targets the entire population in a given area but emphasizes work with disadvantaged groups. Tribal sub plan projects on cashew are examples under this approach. Integrated approaches are generally implemented in the form of large-scale and foreign-funded projects aiming at alleviating mass poverty in rural areas on the basis of 'a simultaneous improvement in the utilization of natural resources and of human potential'. Measures to promote production are coupled with a strong emphasis on self-help. The underlying concept is typically multi-sectoral.

1.7 The cost sharing approach

This approach is based on cashew farmer sharing part of the cost of the extension program. Its purpose is to provide advice and information to facilitate farmers' self-improvement. It assumes that cost-sharing with farmers (who do not have the means to pay the full cost) will promote a program that is more likely to meet local situations and where extension agents are more accountable to local interests. Control and planning is shared by various entities and is responsive to local interests. Success is measured by farmers' willingness and ability to provide some share of the cost, be it individually or through local government units. Problems may arise if local farmers are pressured into investing in unproven enterprises. The approach is found utilized in potato and some spice and medicinal crops but yet to come to cashew sector.

1.8 The educational institution approach

This approach is widely used in cashew extension in India and uses educational institutions which have technical knowledge and some research ability to provide extension services for farmers. Planning is controlled by those in the educational institution. Implementation is through non-formal instruction in groups or individuals through a college or university. Attendance and the extent of participation by cashew farmers in extension activities are the measures of success. While the Cooperative Extension Service (CES) of the United States is still the only system in which the main extension function remains within the university, some developing countries, notably India, have integrated educational institutions into practical extension work. Within the United States of America, state universities have traditionally cooperated with local counties and the US Department of Agriculture in doing extension besides education and research. Within the last 130 years, extension goals of the land-grant colleges have shifted from practical education to technology transfer and, more recently, to a much broader concept of human resource development.

While in most countries, the main contribution of educational institutions to extension will be the training of qualified, dedicated, and responsible personnel, some Indian agricultural universities have come close to the US model with All India Coordinated Research Project (AICRP)s (Ex: AICRP on Cashew) without taking over the full load of extension work. In the field, they have taken over few functions thus supporting general extension work. Remarkable features are direct assessment of clients' needs, user-oriented research, quality training for state personnel, and a strong linkage between academic education and field practice. This model varies from state to state. For example, the Punjab Agricultural University (PAU) has its own multidisciplinary extension team in each district, engaged in adaptive research, training and consultancy. Backed up by extension specialists on campus, they are transmitters and receivers of experiences from researchers, farmers and state extension workers. At PAU, a unique system of processing these experiences is practised. Regular workshops are held which unite university and department staff from research and extension together with outstanding farmers. New findings and feedback are presented, evaluated and published as a 'Package of Practices' to be used by all extension staff for the next season.

Transfer of technology methods adopted by DCR, Puttur

The extension efforts of ICAR, particularly through its institutes are largely of frontline extension programmes. DCR Puttur, over its past 25 years of existence has also made such efforts which are mostly frontline in nature. This article takes a look at the technology backstopping efforts made by the institute since its existence.

Participatory Technology Demonstration Plots

To provide technology backstopping to farmers on frontline cashew production technologies developed by Directorate of Cashew Research and other cashew research stations, cashew demonstration plots based on Farmer Participatory Technology Development (PTD) model were laid out at selected farmers' plots. These PTD cashew gardens serve as demonstration plots to prove the effectiveness of the recommended cashew cultivation practices to farmers while for scientists, these demonstration plots are the tools for assessment and refinement of the recommended practices based on the performance of technologies at micro location level. Laying out of farmer participatory demonstration plots started from the year 1988 as part of the research project; "Transfer of Technology Programmes in Cashew" with the following objectives:

- To provide technology backstopping on frontline cashew production technologies.
- To assess, refine and demonstrate the frontline cashew production technologies.

This research project is externally funded by Directorate of Cashew nut and Cocoa Development, Cochin. Under this programme, every year interested farmers are being selected for demonstrating the frontline cashew production technologies. Interested farmers are requested to apply for the demonstration plots. The application should be addressed to 'The Director, Directorate of Cashew Research', Puttur. In their application, the farmers should mention the root map to their plots. The farmers should have at least two acres of land for demonstration. The plot should be located by the road side, so that the performance of the crop can be observed by the fellow cashew farmers. A team of scientists from DCR assess the plots for their suitability as demonstration plots, after checking the application. Based on report of the team, demonstration farmers will be selected for the particular year. The newly selected demonstration farmers are provided with subsidy and are being trained every year at DCR, Puttur on Cashew Production Technology.

The farmer participatory technology demonstration gardens are regularly visited by the project team and other scientists. The conditions of these plots are assessed based on the criteria viz., removal of forest trees, gap filling, initial training, pruning, soil and water conservation practices, application of manures and fertilizers and plant protection measures. Technical advice is being given to the demonstration farmers based on conditions of the plots.

So far in Dakshina Kannada district a total of 162 model cashew demonstration gardens were laid out. Among the five taluks of the districts, in Puttur taluk more number of plots were laid out and 78 plots were under normal density system whereas remaining 84 plots were under high density planting system. The varieties/types which were distributed as planting material are

Bhaskara, VRI-1, VRI-2; Ullal-1, Ullal-3; H-3-13; VTH 174; BLA 139-1; H-3-17; BPP-3; VTH 59/2; VTH 30/4; T.No.40; Selection-1, 2; Goa 11/6; H 32/4; V-4; NDR-2-1 and Ullal-4. PRESENTLY 26 new FLD plots are taken up in tribal farmer plots under Tribal Sub Plan scheme. The technologies demonstrated include recommended varieties and planting densities.

Thematic campaigns

In order to provide intensive training to the cashew demonstration farmers and cashew growers on important aspects of cashew cultivation viz., soil and water conservation measures (terracing and opening of catchpits), plant protection measures (control of TMB and CSRB) and initial training and pruning, thematic campaigns are being organized. These thematic campaigns were organized in collaboration with NGOs like SKDRDP, Dharmasthala; KJP Research Foundation; Sri Durga Charitable Society and Development Departments.

Prior to the campaign wide publicity was given to attract large number of cashew growers. During campaign, the cashew growers were being exposed technologies through different extension methods viz., exhibition, specially prepared literature; lecture-cum-discussion by experts and field demonstration. Mostly these campaigns were organized at the cashew demonstration plots.

All together, 19 campaigns on SWC measures, 17 campaigns on plant protection measures and 4 campaigns on initial training and pruning were organized and the impact of these campaigns were very high.

Attempts were also made by the Directorate to assess the effectiveness of the campaigns by assessing the knowledge level of the participants on SWC and PP measures before and after the training. It was found that the campaigns were effective in imparting knowledge to the respondents on SWC/PP measures were the number of respondents having higher level of knowledge was more after the training compared to before the training.

Lessons Learnt

- Collaboration with NGO's and village institutions like schools and panchayats encourages participation of the farmers.
- Intensive training using various modes of training increases effectiveness of the programmes.
- These types of programmes serve as a platform in which problems about utilization of cashew and other plantation crops can be discussed and solutions be suggested.

Cashew Field Days / Cashew Days

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 Days are being organized either at DCR, Puttur or at the Cashew demonstration plots of progressive cashew growers.
The farmers / cashew growers on the programme day are explained about the research results at respective plots during the field visit. An exhibition depicting the latest developments in cashew research and useful information about cashew also will be arranged using photos, panels, charts, specimens etc for the benefit of the farmers.

After the field visit and exhibition, seminar-cum-discussion are arranged during which experts in cashew research development and progressive cashew growers share their experience with the other farmers. At the end, question answer session is arranged to clarify the doubts of the farmers on various aspects of cashew cultivation and to express their feedback about the usefulness of the technologies. DCR, Puttur has so far organized 20 such programmes for the benefit of cashew growers, of which a total of 3000 farmers were benefited.

Efforts in Capacity Building

1. Training on "Cashew Production Technology"

In order to educate the extension personnel who are working in development departments in cashew growing states training programmes on "Cashew Production Technology" is being organized regularly. This programme is of two types viz., Refresher course and Special course. Refresher course is being organized for three days whereas special courses are being organized for five days. These programmes are open to extension personnel from all cashew growing states.

During the training, the participants will be trained on the various aspects of cashew cultivation through lecture-cum-discussion mode, visit to various experimental plots, visit to farmers' participatory demonstration plots, visit to private cashew nursery and processing industry. So far 50 such training programmes were conducted at this centre, out of which 1300 participants from all over the cashew growing states participated and benefited.

2. Training on "Vegetative Propagation of Cashew"

To meet out the demand for quality cashew planting material (softwood grafts), which is increasing in all cashew growing states, training programme on vegetative propagation of cashew is being organized regularly. During these training programmes theory and practical sessions on softwood grafting technique and nursery management are being imparted to the participants through intensive training for two days. Participants (nursery assistants / supervisors) from development departments and government owned plantations are regularly being deputed for this programme. So far at DCR, Puttur, 51 such training programmes were organized out of which around 650 participants were trained.

3. Training farm women on cashew apple utilization

Cashew apples are rich in Vitamin C and minerals and have many advantageous effects on human beings. Interestingly, only 10-15 percent of the cashew fruits are utilized by processing, that too to produce country made liquor called 'Fenny' only in Goa. The fruit is wasted mainly due to its disliking qualities such as astringency and arid principles since the fruits are rich in tannin which causes throat and tongue irritation after eating. But the fruits can be made suitable for consumption by removing the undesirable tannin and preparing value added products such as clarified juice, syrup, squash, canned fruits, pickles, jam, jelly and chutney. With this aim DCR, Puttur initiated training programmes on 'Cashew apple utilization' with farm women as the target audience.

During the training the trainees will be imparted training through participatory learning (ie) 'learning by doing'. In addition to this literature on cashew apple utilization will be provided to the trainees. The method demonstrations so far organized were on cashew apple preparation viz., juice/squash, jam and chutney. So far four such programmes were organized out of which a total of 293 farm/rural women were trained.

When the impact of these programmes were assessed by using post-exposure questionnaire (31 respondents) and through mailed questionnaire (20 respondents) it was found that the home level adoption of the demonstrated products was at a average of 50.00% whereas the large scale adoption was poor. The reasons quoted by the respondents for non adoption of the products at a large scale were no awareness about the information on establishment of small scale units, no adequate facilities, non availability of adequate quantity of cashew apples, no adequate time, poor economical background and marketing problems.

4. Other training programmes

Apart from these, training on IPM in Cashew, pruning in cashew and composting of biomass, cashew apple utilization, soil and water conservation in cashew and high density planting and pruning in cashew are also provided. So far, eleven such trainings were conducted covering more than 400 farmers and officials. The Directorate also conducts training programmes on request, apart from the trainings provided under the routine schedule.

Production and supply of planting material

In order to produce and supply quality planting material for cashew (grafts) to the farmers and development departments, two revolving fund schemes were started at Directorate of Cashew Research, Puttur. These are ICAR Revolving Fund Scheme (at Kemminje campus) and DCCD Regional Nursery scheme (at Shantigodu campus). The ICAR revolving fund scheme is functioning from 1990-91 onwards whereas DCCD revolving fund scheme is in place from 1996-97. So far around 17,00,000 grafts were produced and distributed to farmers and development departments from the two revolving fund schemes.

Other extension efforts

Apart from the above routine approaches DCR also participates in exhibitions/expos at important venues across the country by putting up exhibition stall with posters / charts / live specimens depicting the news, information, technologies developed / available on cashew in the country thus aiding in technology dissemination to visiting farmers and other stakeholders. Scientists and technical staff of this Directorate also participated in the exhibitions for explaining technical information to the visitors.

Field visits / Consultancy / Evaluation programmes were also done by the scientists on request. Team of scientists has visited the cashew plots of farmers in all cashew growing states of India upon request. Scientists also participated in various workshops and seminars on cashew organized at various parts of India and presented paper and delivered lectures on various aspects of cashew cultivation. Periodically team of scientists from the directorate participated in the phone-in programme of Doordarshan (Kannada) on Plant Protection and other aspects of cashew. Various Radio talks were delivered on cashew varieties and other cultivation practices and production technologies. Scientists of Directorate delivered talk on various aspects of cashew cultivation and processing aspects. Television interviews are also given on cashew varieties in other states which were telecast in Hindi also by D.D. News. The Scientists also participated in various State Level Workshops cum Seminars on Cashew and delivered talk on topics like cashew production technology, plant protection and training and pruning in cashew. DCR Scientists also visit the Frontline demonstration plots set up under NHM in other districts and states of the country for evaluation on the same.

Future thrust for transfer of technology

DCR focuses on frontline extension of cashew production technologies in line with the mandate of ICAR. Presently, Transfer of Technology efforts by DCR utilises traditional methods which have only moderate reach. The limited staff available for extension and the approach of frontline transfer of technology will further make it difficult in reaching the cashew production technologies to wider audience. The future thrust is on:

- Utilising advances in knowledge management using ICTs towards better technology realization and transfer of technology. Platforms like mobile telephony are to be utilised by implementing mobile advisory services to cashew farmers.

- Retaining interest of new generation cashew farmers and attracting more of them towards cashew farming is a big challenge. Utilising social media marketing by reaching them through innovative social media platforms like Facebook and Twitter is to be explored in this regard. Transfer of technology efforts of DCR has to be made available on social media platforms for increased reach and effective transfer of technology.

- Better utilization of advances in social capital research has to be made towards social mobilization for formation of cashew farmer groups aiding in participatory transfer of latest cashew production technologies.

- Identification of sustainable cashew based farming systems through extension research

will prove to be beneficial towards planning meaningful outreach activities for overall improvement of cashew farmer livelihoods.

- Knowledge about technology fatigue existing in the Cashew sector is presently not much available. More emphasis has to be given for extension research and the knowledge about technology fatigue has to be made available in the coming years. This, along with advances in participatory research has to be used towards successful technology backstopping in the future.

IMPACT OF RECOMMENDED CASHEW PRODUCTION TECHNOLOGIES

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The cashew cultivation in India mainly confines to the states of Kerala, Karnataka, Maharashtra and Goa along the West Coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal along the East Coast region. It is also grown in plains like Chhattisgarh, Gujarat, Bihar and Northeast Hill Regions like Meghalaya, Manipur and Tripura and also in Andaman and Nicobar Islands. In India, it is cultivated in an area of 9.82 lakh ha with a production of 7.28 lakh tonnes and productivity of 772 kg/ha. India has the maximum area (21.6%) under cashew nut and is the third largest producer (17.3%) of raw nuts in the world. After Vietnam, the country is the second largest exporter, accounting for 34 percent of the world's export of cashew kernels. As far as Karnataka State is concerned, Dakshina Kannada District is the major cashew producing region. Increasing production in this district will contribute largely for the Karnataka state's production. Cashew cultivation receives dwindling importance in Dakshina Kannada District in relation to the prices of other crops like arecanut, cocoa, rubber and coconut.

To improve the cashew cultivation scenario of major cashew-growing regions, assessment of the impact of recommended cashew production technologies are very important. Hence, to explore the applicability of technology impact premise in the context of Cashew cultivation, the present study was undertaken at DCR with the objective to measure the impact of different varieties on area, production and productivity of cashew and to measure the impact of recommended production technologies on cashew production and productivity in Dakshina Kannada district of Karnataka. Purposive sampling technique was used to select Dakshina Kannada district since it is a major cashew producing area of Karnataka with presence of two research stations besides other development departments working on cashew and hence having better chances of technology utilization at farm level. Farmers from all the five taluks of the district namely Mangalore, Buntwal, Puttur, Belthangady and Sullia represented the sample.

An 'ex-post-facto cause to effect' design was applied. Detailed questionnaire measuring the adoption status of the farmers, along with their profiles, was developed, pre-tested and utilized for the study. The questionnaire contained 123 questions and took about 45 minutes to elicit information from one household. The data were collected during the 2012-13 through questionnaire and personal interviews. Appropriate statistical measures such as Phi, Spearman's rank correlation and regression analysis were employed to arrive at conclusions. Data was analyzed using Microsoft Excel 2007 and IBM SPSS Statistics Ver. 20.

Adoption and Impact of different varieties on cashew area

Results of the study on impact of recommended varieties on total cashew area showed that highest area under cashew is covered by the variety Ullal-3 (41%) followed by variety Bhaskara (26.62%). It may also be noted that adoption pattern also shows similar trend with variety Ullal-3 adopted by 59 per cent of farmers followed by variety Bhaskara (55%). Most farmers have adopted a minimum of two cashew varieties in their field and 'Ullal-3 +

Bhaskara' combination emerges to be the most popular one in the study area. Varieties Ullal-1 and Vengurla-4 (V-4) were found to cover around 8 percent each of rest of the area. But, these varieties are not popular among farmers with only 13 and 4 percent farmers respectively adopting the said varieties in the district.

Table 1: Variety wise adoption and impact on cashew area

Variety	Adopted by (% farmers) *	Rank	Area covered (%)	Rank
Bhaskara	55	2	26.62	2
NRCC Seln-2	19	3	5.21	5
Madakkathara-2	4	8	4.62	6
Ullal-3	59	1	41.00	1
Ullal-1	13	4	7.66	4
Ullal-4	11	5	2.93	7
VRI-3	7	6	2.66	8
V-4	5	7	8.43	3
V-7	4	8	0.75	9
Other varieties	3	-	0.09	-
Total	92**	-	99.96	-
Seedling origin	8	-	0.04	-
** the percentages won't add upto 100 due to adoption of multiple varieties by single farmer*				
*** represents total percentage of farmers who have adopted released varieties*				

Other varieties like NRCC Selection-2 (5%), Madakkathara-2 (4%), Vridhachalam-3 (VRI-3) (3%), Ullal-4 (3%) and Vengurla-7 (V-7) (1%), have low impact on total cashew area. In total, improved varieties were found to be adopted by 92 percent of the farmers while 8 percent were still continuing with seedling origin plantations. However seedling origin plantations have only negligible coverage in farmer fields (0.04%). Variety wise adoption and impact on area is given in figure 1.

Impact of cashew varieties on production and productivity

Analysis of variety wise impact on cashew production showed that farmers realized highest yield from variety Bhaskara (4.73 kg/tree) followed by Madakkathara-2 (4.45 kg/tree). This was followed by Ullal-1 (3.90 kg/tree) and Ullal-3 (3.87 kg/tree). Ullal-4, another recommended variety was at fifth position with a yield of 3.67 kg/tree while NRCC selection-2 fared low at sixth place with 3.47 kg/tree. Productivity under normal density (8x8m) as well as high density (5x5m) planting was highest for Bhaskara (737.88 & 1882.54 kg/ha) and Madakkathara-2 (694.20 & 1771.10 kg/ha). This was followed by Ullal-1 (608.40 kg/ha), Ullal-3 (603.72 kg/ha) and Ullal-4 (572.52kg/ha) under normal density. Under high density planting system, Ullal-1 (1556.10 kg/ha), Ullal-3 (1540.26 kg/ha) and NRCC Selection-2 (1374.12kg/ha) stood respectively at third, fourth and fifth positions. High density plantations of Ullal-4, VRI-3, V-4, V-7 and other varieties were not observed during data collection for this study. Variety wise impact on production and productivity is presented in table: 2.

Table 2: Varietal impact on production and productivity of cashew

Sl. No	Variety	Production (kg/tree)**	Rank	Productivity (kg/ha) under normal (8x8m) density	Rank	Productivity (kg/ha) under high (5x5m) density	Rank
1.	Bhaskara	4.73	1	737.88	1	1882.54	1
2.	NRCC Seln-2	3.47	6	541.32	6	1374.12	5
3.	Madakkathara-2	4.45	2	694.20	2	1771.10	2
4.	Ullal-3	3.87	4	603.72	4	1540.26	4
5.	Ullal-1	3.90	3	608.40	3	1556.10	3
6.	Ullal-4	3.67	5	572.52	5	-	-
7.	VRI-3	3.06	7	477.36	7	-	-
8.	V-4	1.51	9	235.56	9	-	-
9.	V-7	3.00	8	468.00	8	-	-
10.	Other varieties	2.23	-	347.88	-	-	-
11.	Seedling origin	1.23	-	147.60	-	-	
*** In trees above 5 years of age*							

Bhaskara variety was released during March 2006 for coastal region of Karnataka. This variety is having midseason flowering habit (Dec-Mar) with a flowering duration of 60 days and has potential to escape from the attack of the tea mosquito bug (TMB) under low to moderate outbreak situation. The average yield was reported to be 10.7 kg/tree at DCR. The nut and kernel weight are 7.4 g and 2.2 g respectively. The shelling percentage is 30.6 and kernel grade conforms to export grade W240. The potential to escape from the attack of the tea mosquito bug (TMB) along with very good yield potential have definitely favoured this variety in its high adoption among farmers of Dakshina Kannada district. Madakkathara-2 (NDR 2-1) is a selection released in 1987. The mean yield reported from research station is 17 kg/tree. The nuts are bold (7.3 g nut weight) with shelling percentage of 26.2. Kernel weight is 2g having a count of W 240 export grade. However, this highly yielding variety was found to be adopted by only 4 percent of the farmers mainly due to low awareness in this district.

Ullal-3 is a selection released in 1993 from ARS, Ullal. It is early in flowering (November - January) and fruiting period is very short (50-60 days). The fruiting is from January to March and sometimes starts from last week of December. It is a high yielding variety with average yield of 14.7 kg/tree. The nut size is medium with nut weight of 7g. The shelling percentage is 30 and the kernel grade conforming to W 210 grade. Its mid season nature coupled with higher yields seems to have made it a favourite among farmers. Ullal-1 is a selection released by ARS, Ullal in 1984. The average yield is 16 kg/tree. The duration of harvest is long (about 110 days). The nut weight is 6.7g with shelling percentage of 30.7. Even though the variety recorded slightly higher yields (3.90 kg/tree) in field compared to Ullal-3 (3.87 kg/tree), the adoption by farmers (13%) was found to be far below than its counterpart Ullal-3 (59%) which tops in adoption among farmers in all varieties.

Production and productivity profile of cashew farmers

The production and productivity profile of cashew farmers showed that farmers achieved a mean production of 425 kg and productivity of 2.92 kg/tree. In case of production, majority fell in to medium (40%) and low (43%) producer categories while they were almost equally divided into high (33%), medium (36%) and low (31%) categories with respect to productivity achieved.

Table 3: Classification of farmers based on production and productivity of cashew

Categories	Production			Productivity		
	f	%	Range	f	%	Range
High	13	17	>674	25	33	>3.96
Medium	30	40	674-177	27	36	3.96-1.87
Low	32	43	<177	23	31	<1.87
Mean	425			2.92		
SD	497			2.09		

Technology impact on production and productivity of cashew

The recommended cashew production technologies starting with recommended varieties were categorized to eight groups such as Varieties, Planting and initial care, Soil and water conservation, Manures and fertilizers, Pruning and training, Plant protection, Intercropping and Harvesting and post harvest technologies. Their impact on production and productivity were studied separately and are presented here.

Adoption and relationship of cashew production technologies towards cashew production and productivity

The overall adoption of cashew production technologies had received an index score of 44. Majority (51%) of the farmers belonged to medium adopter category while rest was almost equally divided between high (25%) and low (24%) categories (Table 4). Most cashew production technologies scored moderate to poor adoption index with exception of recommended varieties (72) and planting and initial care technology (73). Soil and water conservation technology (48) and pruning and training (43) showed medium adoption index while manures and fertilizers (30), plant protection (20), intercropping (22) and harvesting and post harvest technologies (43) scored low adoption index. Correlation analysis showed that four technologies; soil and water conservation, pruning and training, plant protection and harvesting and post harvest technologies had highly significant relation with the cashew production achieved by farmers (table 5) while pruning and training had a significant relation with the productivity of cashew.

Table 4: Adoption index of farmers for cashew production technologies

Sl. No	Category	Range	Respondents	
			f	%
1	Low (<Mean-1/2S.D)	<36.27	18	24
2	Medium (Mean(+/-)1/2S.D)	36.27-51.39	36	51
3	High (>Mean+1/2S.D)	>51.39	19	25
Mean= 43.83, S.D=15.12				

Cashew farmers were found to adopt maximum practices under planting and initial care (Rank 1) followed by recommended varieties. Also, these practices were easy to adopt and initial interest plays a major role in the high adoption rate of this technology. Soil and water conservation techniques were also moderately followed by most of the farmers (Rank 3). The increased availability of heavy machineries at affordable per hour rates for land leveling, pit digging, terrace making etc. is a major reason behind this. Also, the practices under this technology are mostly adopted along with or in continuance with planting and after care thereby increasing its chance of adoption due to initial interest. Accordingly, the technology also showed a positive significant relationship (r=0.344**) with cashew production achieved by farmers. Adoption of pruning and training along with harvesting and post harvest technologies stood together at fourth place with adoption index of 43. Pruning and training was also found to have significant relationship with production (r=0.338**) as well as productivity (r=0.271*) of cashew. Harvesting and post harvest technologies was also found to have highly significant relationship with production (r=0.321**). Adoption of manures and fertilizers was found to be poor among farmers with adoption index of 30. Intercropping was another technology which was poorly adopted (Rank 6). Low to medium adoption with respect to most cashew production technologies could be attributed to the fact that farmers are yet to realize the importance of recommended technologies on the yield and potential economic benefits that accrues from their adoption.

Table 5: Relationship of cashew production technologies towards cashew production and productivity

Technology	Adoption Index	Production	Productivity
		'r' value	'r' value
Varieties	72	0.174 NS	0.020 NS
Planting and Initial Care	73	0.201 NS	-0.011 NS
Soil and Water Conservation	48	0.344**	0.165 NS
Manures and Fertilizers	30	0.094 NS	-0.042 NS
Pruning and Training	43	0.338**	0.271*
Plant Protection	20	0.345**	0.146 NS
Intercropping	22	0.062 NS	0.014 NS
Harvesting and Post Harvest	43	0.321**	0.123 NS
Overall adoption	44	-	-
NS – Non-Significant, ** - Significant at 1 % level, * - Significant at 5 % level			

Plant protection, which is one of the most important components affecting production, scored the lowest adoption index (20) among cashew farmers in the present study. Non-adoption was particularly high for plant protection technologies against Cashew Stem and Root Borer (CSRB) due to the complexity of the technology while majority had adopted measures against Tea Mosquito Bug (TMB) due to less complexity, higher trialability and observability of results in comparison to measures recommended against CSRB. The technology showed highly significant positive relation (r=0.345**) with cashew production. It is obvious from these findings that there is tremendous scope in the region for increasing adoption of recommended cashew production technologies.

Contribution of cashew production technologies towards variability in cashew production and productivity

Regression analysis revealed the extent of contribution of each production technology towards variability found in levels of cashew production and productivity in the district (Table 6). Plant protection component which scored the lowest adoption index and also showed highly significant relation (r=0.345**) with cashew production achieved by farmers emerged as the most significant contributor towards cashew production (b=0.339**) in the district. This clearly indicates that adoption of plant protection techniques cannot be ignored at any cost if cashew production in the district has to be improved. The findings also calls for development of plant protection measures which are user friendly (less complex), having relative advantage over existing technology and also compatible with farmer situations. Soil and water conservation technology which showed a significant relationship (r=0.344**) with cashew production, is also found to have a significant contribution towards explaining the variability in cashew production (b=0.326*). Interestingly, intercropping; another poorly adopted technology was also found to have a significant contribution towards explaining the variability in cashew production (b=0.243*). Recommended varieties, manures and fertilizers and harvesting and post harvest technologies were found to have a non-significant but negative contribution towards cashew production. This is explained by the fact that in case of recommended varieties, even though the study found that highest production was given by Bhaskara, Madakkathara – 2, Ullal - 1 and Ullal - 3 varieties, the same varieties covered only 26.62, 5.21, 7.66 and 41.00 percent respectively of total area under cashew cultivation. Thus, the findings make it clear that by increasing the adoption and area coverage of above varieties we can bring a quantum increase in cashew production in the district.

Table 6: Contribution of cashew production technologies towards variability in cashew production and productivity

Technology	Production	Productivity
	'b' value	'b' value
Varieties	-0.131 NS	-0.077 NS
Planting and Initial Care	0.037 NS	-0.159 NS
Soil and Water Conservation	0.326*	0.208 NS
Manures and Fertilizers	-0.195 NS	-0.184 NS
Pruning and Training	0.178 NS	0.313*
Plant Protection	0.339**	0.139 NS
Intercropping	0.243*	-0.097 NS
Harvesting and Post Harvest	-0.012 NS	0.024 NS
	R^2 = 0.406	R^2 = 0.149
NS – Non-Significant, ** - Significant at 1 % level, * - Significant at 5 % level		

Farmers in the study area were found to have poor adoption in case of manures and fertilizers for cashew. The study also found that harvesting cashew from the trees itself is a common practice to avoid theft and this coupled with improper drying practices including less number of drying days has contributed more volume to the cashew production. If proper harvesting and drying practices are followed it will decrease the total volume of cashew thus explaining the negative relation. Similarly by increasing the adoption levels of manures and fertilizers in cashew and by adopting proper harvesting and post harvest drying techniques the cashew production can be further improved. All the recommended production

technologies together could explain only up to 40 percent of variability in cashew production (R^2 = 0.406). Adoption of pruning and training in cashew orchards was found to have a significant contribution towards increasing the per unit productivity of cashew orchards. However the adoption level of this technology is very low at present. The study reveals that increasing adoption of soil and water conservation techniques and development and popularization of user friendly plant protection measures can contribute largely to increased cashew production while increasing adoption of pruning and training in cashew orchards can significantly increase the per unit productivity of cashew orchards. The results clearly indicate that socio-economic and bio-physical factors along with policy environment have a larger contribution in explaining cashew production and productivity and technology component alone cannot be expected to bring a positive impact. Understanding the above dynamics in technology impact can help researchers and extension agencies working in cashew sector to design better innovations and effective outreach strategies.

Socio-economic impact of cashew cultivation

Ten major social and economic impact indicators were studied to arrive at the socio-economic impact of cashew farming among the respondents. Study on impact on cropping pattern didn't record much of change with only 17 percent of farmers increasing area under cashew over the years (1.5 acres) while only negligible percent (3%) of them purchased new lands (2 acres) for cashew cultivation. Impact on labour engagement was also low with only 20 percent farmers hiring labour for cashew and only one tenth of them opting for increased family labour engagement (11%). The hiring of labour was noticed particularly for plant protection and harvesting operations with farmers mostly engaging one to two labourers during this period. While a large majority (85%) reported no change in farm expenditure due to cashew cultivation, 43 percent of farmers reported an increase in farm income due to cashew cultivation. Farmers reported an average increase of Rs. 2272/year in farm expenditure and Rs. 4188/year in farm income due to cashew cultivation. Resultant increase in family incomes was also reported by 36 percent of the farmers to the average of Rs. 4259/year followed by an average increase of Rs. 2666/year in their family expenditure. The above indicators were measured as average for preceding 10 years of cashew cultivation.

Analysis of social impact presented a better picture in comparison to economic impact with majority (61%) of the farmers reporting increased social participation while nearly two-third (67%) majority could increase their contacts with extension agencies and research institutes due to cashew cultivation. Majority (56%) reported increase in their mass media exposure while a large majority (63%) reported an increase in their opinion leadership status due to cashew cultivation. It can clearly be seen that the social benefits of cashew cultivation are far more than the economic benefits.

Classification of cashew farmers based on the social and economic benefits accrued shows that nearly half of the cashew farmers (47%) belong to high social impact category while in case of economic impact large majority (80%) belonged to low benefits category. Overall, nearly half of the cashew farmers (47%) recorded medium levels of socio-economic impact (Table 16). It may be noted that the low level of economic impacts are compensated to a large extent by the high social impact due to cashew cultivation.

Constraints faced by farmers in cashew cultivation

The socio-economic impact of cashew cultivation is largely influenced by the constraints faced by farmers. Studies conducted by DCR revealed 12 constraints as reported by farmers and are classified under technical, management, economic/marketing and processing constraints. Majority (83 %) reported poor price and the high price fluctuations in market for raw cashew nut as the major constraint (Rank 1). Lack of cashew farmer associations/groups and availability of cashew nuts from African nations allow cashew nut processors to manipulate the raw cashew nut prices. Low availability of hired labour was the second biggest constraint reported (71%). Migration of workforce to urban areas, easy job availability through MNREGA scheme and respectable job avenues in many private firms for women have acted as reasons for low availability of workforce in villages. Attack of tea mosquito bug and resultant crop loss (41%) and death of yielding trees due to cashew stem and root borer attack (35%) were also major technical constraints (Rank 3 & 4). This is a matter of concern since cashew yields are largely influenced by the attack of Tea Mosquito Bug (TMB) while attack of Cashew Stem and Root Borer (CSRB) eliminates the crop itself.

Flower drying (Rank 5) and poor yield in some varieties (Rank 6) like NRCC selection-2 (flower drying), VRI-3, V-4 and V-7 (poor yield) were also major constraints. Problems in collection of nuts from large plantations and the resultant theft due to delay or inaccessibility was another constraint reported by farmers. Price control and manipulation by cashew processors were also identified as a constraint by certain section of farmers. Cultivation of cashew in poor soils and wastage of cashew apple due to lack of processing avenues were the other constraints cited by farmers.