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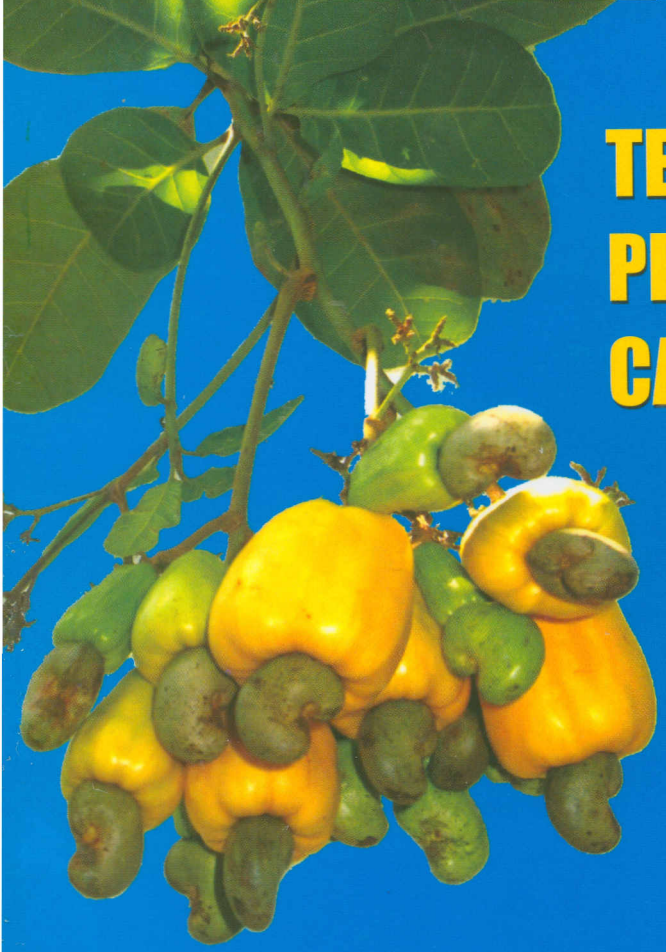

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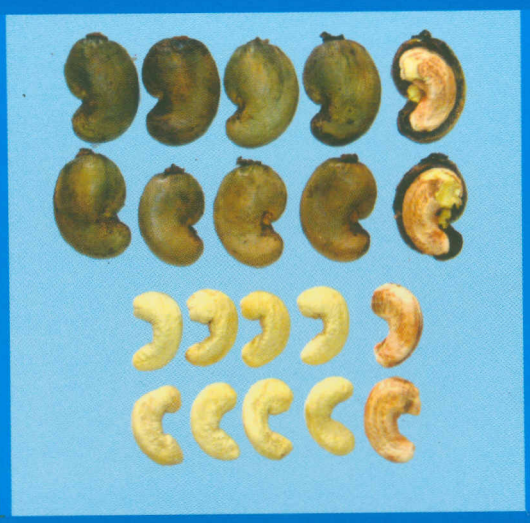

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ICAR

Indian Council of Agricultural Research
ICAR Research Complex For Goa
Ela, Old Goa - 403 402, Goa, India

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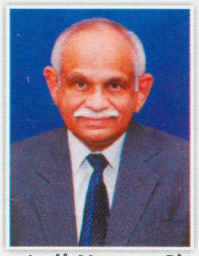

FOREWORD

Dr. Anil Kumar Singh
Deputy Director General (NRM)

Indian Council of Agricultural Research
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Portuguese introduced cashew into India on the Arabian sea coasts of pre-independent Goa during 16th century. Presently, it is being cultivated in coastal states on both Eastern and Western Coasts and also in non-traditional areas like plains of Karnataka, Chattisgarh, and in Tripura, Meghalaya, Assam and Manipur of North Eastern Hill Region of the country. This crop is earning about Rs.2500 crorers of foreign exchange annually. From the time its introduction, cashew has become important crop of the state entwined in the traditional fabric of Goans' life style. Now, this crop has become main commercial crop of the state covering an area of about 55000 hectares mainly on hilly and undulated terrains in the state. It is imperative to note that the total raw nut production coming out from this area is inadequate and unable to cater to the needs of the local processing units of the state. to only able to meeting Though the area is steadily increasing, production is fluctuating from year to year due to many factors like changing weather, incidence of pests and disease, poor management practices, poor yielding trees and the like, which need vibrant research and management aspects.

It is evident that, cashew plantations in the state of Goa are indeed a genetic treasure of potential genotypes, since, for a long time, seed propagation was in vogue. It is, therefore, prerogative to emphasize on collection and conservation of vital germplasm resources for the posterity. Aptly, the initial cashew research work in Goa began with this point in view, besides the introduction of HYVs from other research stations for evaluation in Goa. Three decades' research, has culminated in the introduction of improved varieties like Vengurla-4, etc.; selection of two high yielding local varieties (Goa-1, and Tiswadi-3) and standardizing the soft wood grafting , top-working and in situ grafting techniques for improved varieties. Studies have vividly shown that the *in situ* moisture conservation greatly benefit the crop for realizing the higher nut yield. Crop management aspects, however, also need to be addressed in future research programmes that may enable to offer complete crop production technology package to growers. This technical bulletin, "Techniques and Practices for cashew production" can serve as a benchmark document for formulating future research and production strategies and provides the relevant information to researchers and farmers alike. I wish, this Technical Bulletin, will be useful to all those involved in cashew industry in general and Goa in particular. I am delighted to say that the ICAR Research Complex for Goa is releasing few more new varieties of cashew for Goa and is evolving several farmer friendly agro-techniques in the immediate near future which help boost the production and productivity of cashew country.

(A. K. Singh)

PREFACE

Dietary importance of cashew kernels owing to their unique combinations of ıutrient supplements like proteins, carbohydrates, lipids, vitamins and minerals, ıas brought cashew to the status of international trade crop. As a result of this, ndia, a monopoly till recently, is facing stiff competition in the international narket. Moreover, India needs to double the production and productivity not only o meet the requirements of domestic processing sector but also to maintain the tatus in international scenario so as to earn foreign exchange earnings.

Cashew is the main commercial plantation crop of Goa which occupies more han 50% of the cultivated area in the state. It is, in fact, quintessential part of social abric and economic machinery of the state. Though, cashew was introduced over our hundred years ago, till recently, it was grown as waste land crop. Research on :ashew was initiated in Goa about three decades ago. It was the time when there vas no information about recommended package of practices, improved varieties ınd propagation techniques available in the state and growers were unaware of he real economic potential of the crop. Then onwards, a lot of information on :echnology development took place by virtue of concerted research efforts. This Technical Bulletin is compilation of such information about the latest Techniques ınd Improved Practices for Cashew Production, which will be useful for all those ıealing with this crop, right from students to the cashew farmers and policy ɔlaners.

In this endeavour, we duly acknowledge with great concern the support and ɛncouragement received from the present and former directors, scientist colleagues and all the cooperation and assistance extended by the Technical and Administrative Staff. Authors copiously acknowledge the facilities and encouragement sought from The Indian Coucil of Agricultural Research, New Delhi.

August, 2010

- Authors

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1 INTRODUCTION

Cashew (*Anacardium occidentale* L.), a member of Anacardiaceae family, is a native of North East Brazil in Latin America. Being an evergreen tree of tropics, this is cultivated in more than 28 countries in tropical region on either side of the equator for its delightful nutritious kernels and apple and cashew nut shell liquid (CNSL).

Cashew kernels are excellent nutritive supplements owing to their unique combination of proteins (21%), fat (4750.%), carbohydrates (18-20%), minerals, vitamins and dietary fibre, and thus, find place from tasty dry nuts, sweet dishes to a range of confectionary products all over the world. While, cashew apples, the pseudo fruits are rich in ascorbic acid (40 390 mg/100 g), sugars, minerals and other anti-oxidants. Theses apples although wasted in huge quantities in other states, are mainly used in Goa for preparation a popular alcoholic beverage called "Feni", a GI registered product. However, apples, are used in limited quantities for preparing concentrated juice, syrup, ready to drink beverage, jam, nectar, frozen pulp, fruit wafers, wine, vinegar, *etc.* CNSL finds extensive use in paints, textile, resin industries and ship building industries and is, thus, considered as an important by product of high trade value.

From the time of its introduction in India on the coasts of Goa in 1570 AD by the Portuguese for soil conservation, cashew has adapted very well to Indian conditions. Cashew as on today, has gained special status in the international scenario as a plantation crop of considerable foreign exchange earner. At present, this crop is cultivated in an area of about 40.97 lakh hectares with an annual estimated global production of 37.20 lakh tonnes of raw nuts (FAO, 2010). Though India is one of the major producers of cashew nut in the world, it imports huge quantity of raw nuts. Brazil, Vietnam, Tanzania, Mozambique, Indonesia, Sri Lanka, Australia and Nigeria are the other countries making significant contribution to the world's cashew production. In India, Kerala, Karnataka, Goa and Maharashtra on West Coast; Tamil Nadu, Andhra Pradesh, Orissa and West Bengal on East coast and Tripura, Meghalaya, Assam and Manipur in the North Eastern Hill Region are the major cashew growing states. Maharashtra leads in production with 2.25 lakh metric tones and productivity of 1500kg/ha., while Andhra Pradesh leads in area (1.82 lakh hectares) with production and productivity of 1.12 lakh MT and 920kg/ha respectively (DCCD, 2008-09). Indigenous cashew production, however, is far inadequate to meet the raw nut.

Requirement (12 lakh MT annually) of the processing industries in the country. Situation is same in respect of Goa state also. In Goa, cashew crop is cultivated in about 55,000 hectares (Figure 1) with an annual raw nut production estimated at 30,000 MT with the productivity level of 700 kg/ha. This production is inadequate to meet the raw nut requirement of processing units located in Goa state too.

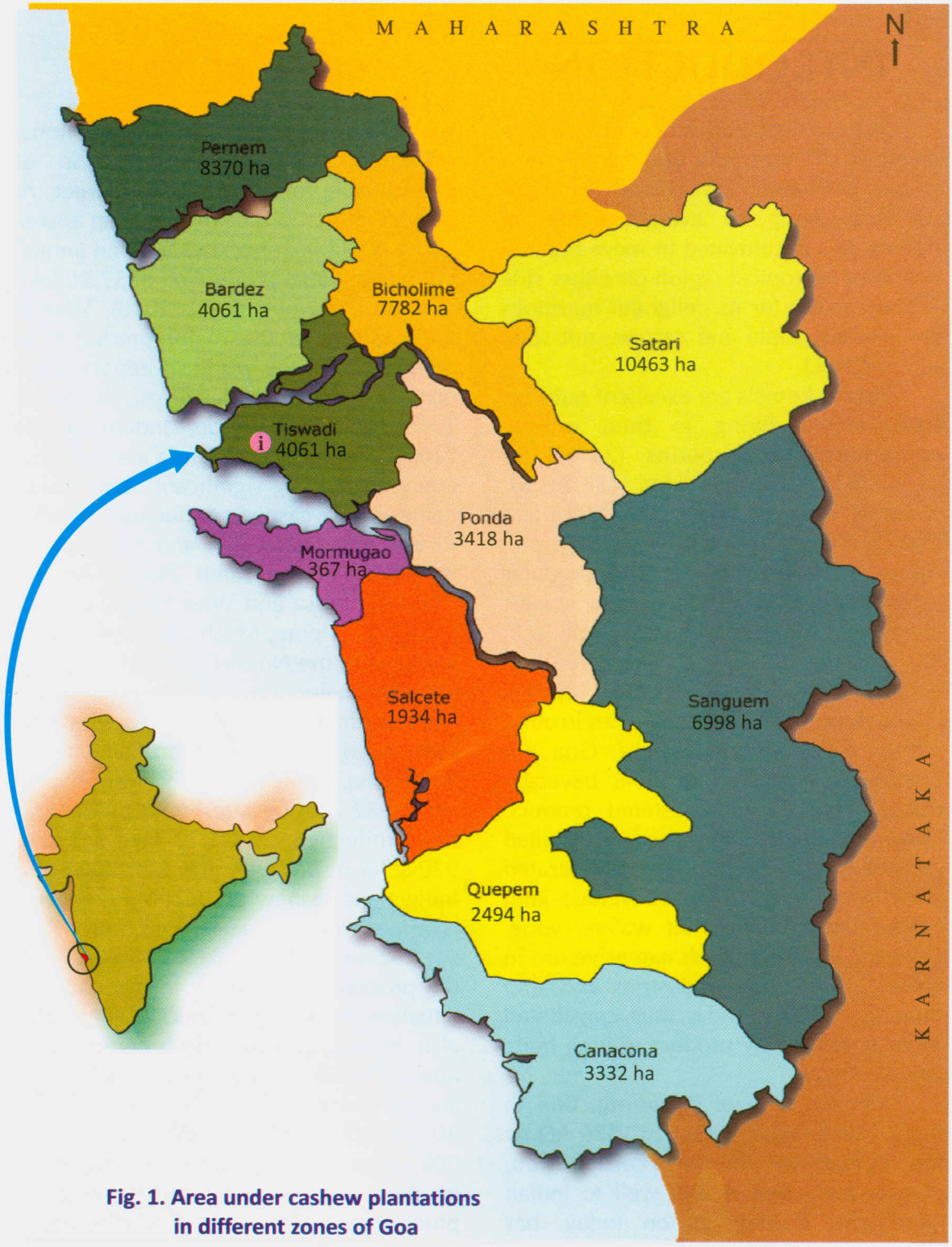


Fig. 1. Area under cashew plantations in different zones of Goa

STATE	2003-04			2004-05			2005-06			2006-07			2007-08			2008-09		
	A	P	APY	A	P	APY	A	P	APY	A	P	APY	A	P	APY	A	P	APY
Kerala	101	95	890	102	64	900	80	67	900	80	72	900	84	78	900	70	75	90
Karnataka	94	46	500	95	43	680	100	45	700	102	52	700	103	56	710	107	60	720
Goa	55	32	690	55	26	660	55	27	690	55	29	690	55	31	700	55	30	700
Maharashtra	148	120	1100	160	174	1200	160	183	1300	164	197	1500	167	210	1500	170	225	1500
Tamil Nadu	95	51	600	105	53	610	121	56	640	123	60	670	123	65	700	131	68	710
Andhra Pradesh	136	95	750	150	88	840	170	92	880	171	99	890	171	107	900	182	112	920
Orissa	124	71	850	126	74	810	120	78	860	125	84	860	131	90	860	137	95	865
West Bengal	9	9	760	9	8	800	10	10	950	10	10	1000	10	10	1000	11	11	1000
Gujarat	-	-	-	-	-	-	4	4	900	4	4	900	4	4	1000	6	4	700
NE States	-	-	-	-	-	-	14	10	640	15	11	700	15	12	750	16	12	750
Others	18	16	790	18	14	800	3	1	400	5	2	500	5	2	500	8	3	460
TOTAL	780	535	800	820	544	810	837	573	815	854	620	820	868	665	860	893	695	900

Source : DCCD, Cochin

A - Area in '000 Ha.
P - Production in '000 MT.
APY - Average Productivity in Kg per Hectare

2 CLIMATE AND SOIL

Although an introduction from Brazil in South America, because of its adaptive ability in wide range of agro climatic conditions, cashew is cultivated in varied climates and soil types in different parts in India. Hot humid tropical conditions in summer with day temperature of 30-38 °C and relative humidity of more than 50 per cent are congenial for its cultivation. It comes up well up to an altitude of 700m from msl.

Goa receives annual rainfall of 2800-3200 mm, confined to the short period of four months from June September. Due to this unimodal pattern of rainfall resulting in long dry spell, especially during the critical period of flowering and fruit set, cashew suffers from severe physiological stress in the lateritic soils of Goa.

Cashew can be cultivated in almost all types of soils ranging from coastal sandy and red lateritic soils to red sandy loam soils in plains and soils with fertility status. It is largely believed that cashew is waste-land crop and does not need much care, as a result of which it is given least attention. This mind-set needs to be changed. It grows well and performs better in well drained red sandy loams with pH in the range of 5.8 to 6.8. Acidic soils below this pH need to be ameliorated with proper soil amelioration practices. Solis with poor drainage and water logging problems with excessive alkalinity and salinity are not suitable for cultivation of cashew and hence may be avoided for commercial orchards.

Until recent times, cashew was considered as "a waste land crop" and was not given due impetus in crop management, ought to be given for any commercially important crop. Even today, high yielding improved varieties are cultivated under rainfed conditions in neglected marginal land. However, studies have indicated that cashew tremendously responds to irrigation and nutrition management. In Goa, majority cashew plantations find place in hilly, undulated topography and degraded soils with poor water holding capacity and low fertility.

These soils generally vary considerably in depth, texture and physico-chemical properties and fertility due to continuous leaching and therefore need to be replenished with proper nutrient management practices.

3 VARIETIES

At present, more than forty high yielding cashew varieties are available in the country for commercial cultivation in different cashew growing states (Table 1).

Majority cashew plantations in Goa are of seedling progeny of non- descript types with varied degree of nut and apple yield performance. But, new plantations are coming up with improved high yielding varieties recommended for commercial cultivation in the state of Goa. Following are the suitable varieties for Goa.

Goa-1(Balli-2): It is a clonal selection from a high yielding plus tree located in Balli village of Quepem Zone of Goa. It is a mid season variety bearing medium nuts (7.6-7.8g) in bunches (Fig. 2). Nuts on processing yield more than 29-31 per cent kernels of W210-W240 grade. Yellow apples are juicy and bigger in size (>70g). This variety yields 9-12 kg of raw nuts per tree at the age 10 years. Because of its mid season bearing nature, it escapes the attack of TMB in the early part of the season (Desai *et al.*, 2001).

Table-1. High yielding cashew varieties suitable for commercial cultivation in different states in the country.

Goa: Goa-1, Vengurla-4, Vengurla7, Vengurla-8, Bhaskara (Goa 11/6)
Maharashtra: Vengurla-1, Vengurla-4, Vengurla-6, Vengurla-7, Vengurla-8
Kerala: Madakkathara-1, Madakkathara-2, Dhana, Kanaka, Dhana,Kanaka, Sulabha, Priyanka, Amrutha, Raghava, Damodara, Poornima and K-22-1
Karnataka : NRCC Sel-2, Ullal-1, Ullal-3, Ullal-4, UN-50, Vengurla, 1, Vengurla-4, Vengurla-6 and Vengurla-7 for coastal Karnataka and Chintamani-1 for Maidan (Plains).
West Bengal: Jhargram-1, and BPP-8
Orissa: Bhubaneshwar-1, BPP-8 and Dhana
Andhra Pradesh: BPP-4, BPP-6, BPP-8
Tamil Nadu: VRI-1,VRI-2, VRI-3
North Eastern Hill Region: Ullal-3, Ullal-4, Vengurla-1 and Vengurla-4

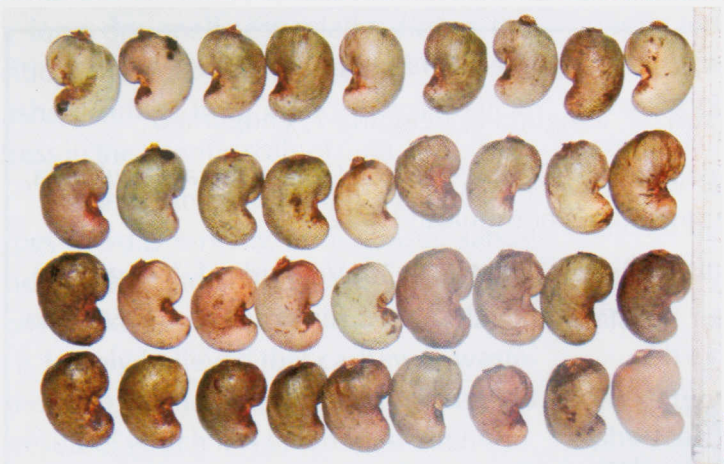
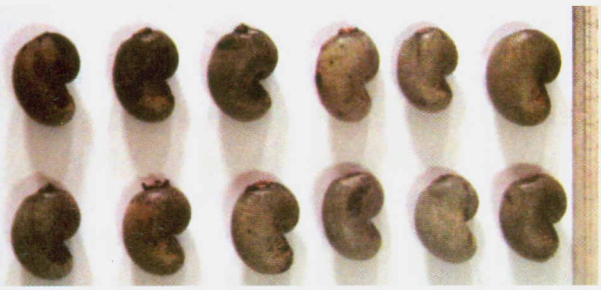


Fig. 2. Goa-1 (Balli-2) Cashew :
Clusters of fruits, nuts, apples and kernels



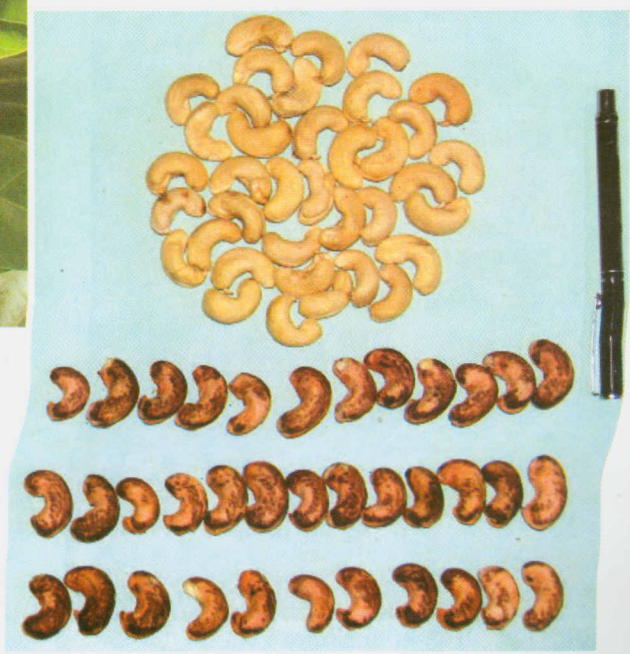


Fig. 3. Cashew apples, nuts and Kernels of **Vengurla-4 variety**

Vengurla-4: It is an early bearing hybrid variety of the cross : Midnapur Red X Vetore-56. Average nut yield is about 15kg per tree. It yields medium nuts(>7.5g) and red apples are of medium size.

Vengurla-7: It is a hybrid variety of the cross Vengurla-3 X M 10/4. Nuts are bold and yellow coloured apples are medium in size.

Vengurla-8: It is hybrid variety of the cross Vengurla-4 X M10/4. Nuts are medium bold and apples are yellow and medium sized.

Bhaskara (Goa 11/6): It is a clonal selection from a mother tree for higher nut yield (10-12 kg/tree) and tolerance to tea mosquito bug, located in Gaondongrim village, Cancona taluka of Goa. Nuts are of medium size (7.4g) with 30 per cent of shelling (Fig. 4).

Fig. 4. Bhaskara variety

Studies have indicated that new selections namely Tiswadi - 3, KN 2/98 and GNJ - 2 also could be promising new varieties for Goa.

Fig. 5. Tiswadi - 3

Fig. 6. KN 2/98

Fig. 7. GNJ - 2

3 PROPAGATION

Cashew is propagated by both seeds and also by vegetative methods. Seed propagation results in enormous variability in the seedling progeny. Therefore, high yielding cashew varieties are commercially propagated by different vegetative methods to produce true to type planting material, which are described below.

A. Soft wood grafting: This is the most popular and the best method for commercial multiplication of improved cashew varieties and found to be suitable for propagation almost round the year. However, higher success rate of grafting can be achieved during June to October due to abundance of mature scion shoots, favourable temperature and higher relative humidity conditions. Various steps of softwood grafting technique are:

A. 1. Raising of root stock:

- Potting mixture in the proportion of 1part of red soil : 1 part of river sand : 1 part of Farm yard manure/compost has to be prepared with rock phosphate (40-50g/10kg mixture) added to it. This is filled in high density polythene bags of 25cm X 15cm size having thickness of 250-300 gauge, with holes punched on them for proper drainage for raising the root stock seedlings.
- Healthy and fully matured uniform sized seeds should be collected from the peak time in the season, preferably from a single variety and sun-dried for 2-3 days. Such selected seeds can be stored for about 6-8 months in gunny bags or plastic bags which can be further used for raising the root stocks. Such bags should be store in dry and cool place free from rodents.
- Heavy seeds screened by removing the seeds floating in water should be used for sowing. Such seeds, pre soaked overnight have to dibbled with stalk-end upwards, 3-4 cm deep in the centre of the polythene bags filled with potting mixture and watered immediately. Seeds can be sown in fortnightly batches to ensure the availability of root stock seedlings continuously for grafting. Seeds, pre-germinated in moist sand bed, can also be used for sowing to ensure the seedling in each polythene bag filled with growth medium.
- Watering should be done depending on the seasonal requirements (daily in summer) to ensue the proper germination which takes about 2-3 weeks. Healthy seedlings of 7-8 weeks old (50-60 days) after germination, are used for soft wood grafting. Collar rot or damping off disease during rainy season can be controlled by spraying Bordeaux mixture (1%) or Bavistin (1%) at fortnightly interval. Sucking

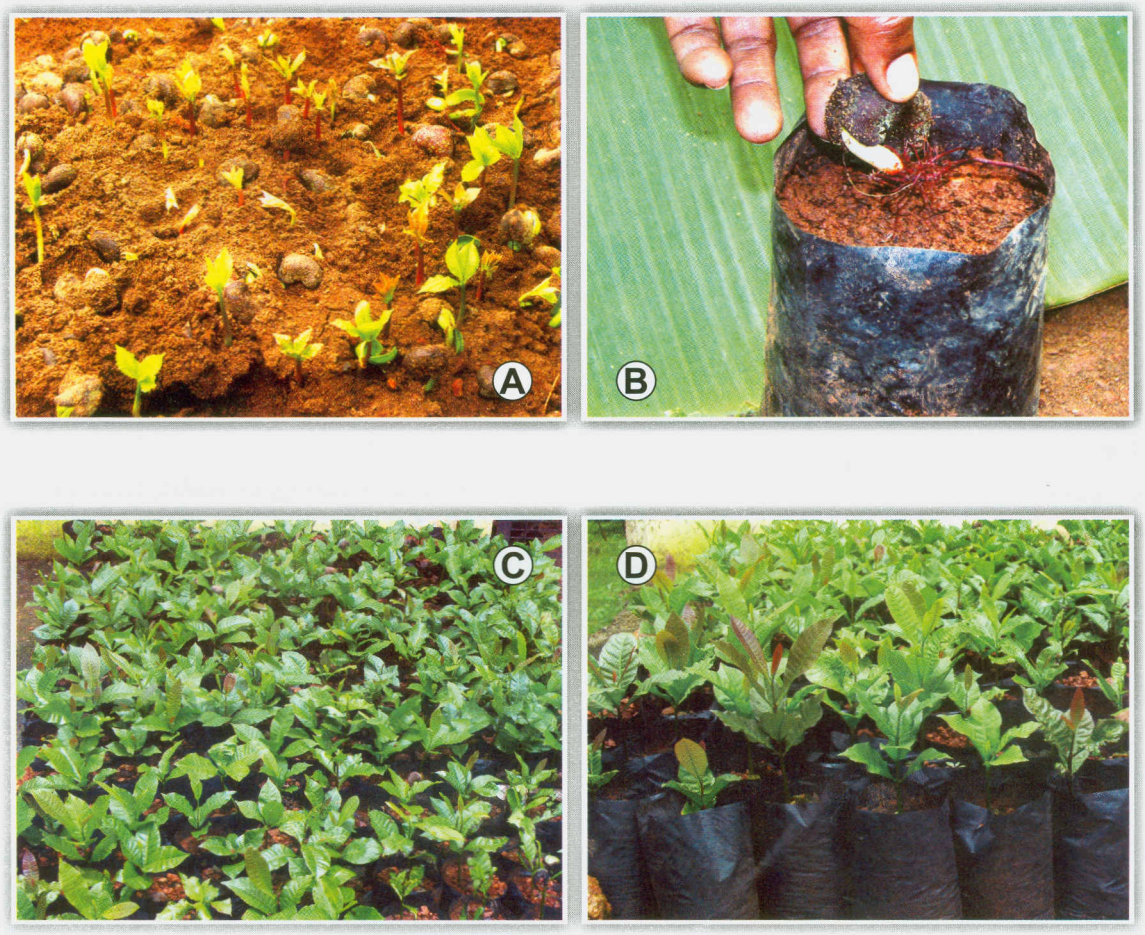


Fig. 8. Raising of root stock

A - Germination of seeds in sand bed

B - Sowing of pre-germinated seeds in poly bags

C - Uniform growth of seedlings

D - Healthy seedlings becoming ready for root stock

Pre-curing of scion shoots

Collection of scion sticks

Preparation of scion sticks

Selection and preparation of root stock

Fig. 9. Preparation of scions for soft wood grafting

pests like Tea Mosquito Bug (TMB) and Thrips can be controlled by spraying Monocrotophos or Quinolphos (1.5 ml/litre of water) during the growth of seedlings.

A. 2. Preparation and Collection of scion sticks: In the scion bank, healthy, non-flowering matured shoots of 4-5 months of current growth on desired variety are to be selected and precured by clipping off the leaves with part of petiole retained on the shoot, with help of a Secateur (Fig. 9). Precuring should be done, batch wise at fortnightly interval, 10-12 days prior to grafting in order to stimulate the dormant buds on the shoots which will ensure the higher rate of graft take. Such pre-cured shoots of 15-20 cm length (scion sticks)which will be having bulged buds are to be collected early in the morning on the day of grafting.

A. 3. Tieing the graft :

- Healthy root stock seedlings of 7- 8 weeks old (50-60 days) are selected for grafting. On the root stock seedling, very tender portion of terminal shoot is nipped off and all the lateral leaves except the lower most two pairs, are removed using the grafting knife. A transverse downward cut is given in the soft wood portion on the decapitated stem (15-20cm above) to make a cleft of 5-6 cm deep. From the inner portion of cleft lips at the top, some portion of wood has to be removed to ensure smooth union at the grafting joint without any dead wood.
- From the scions collected, a scion stick matching to the clefted root stock is selected and cut freshly at the bottom to reduce it to required length (10cm) and sharpened to wedge shape by giving smooth inward slant cuts at one stroke longitudinally downwards (up to 5-6 cm) on opposite sides on the scion stick so that the bark portion is intact on the other sides.
- The wedge shaped scion stick is inserted in to the cleft of the root stock and the cleft is closed in such a way that the cambial portion of both the scion stick and root stock comes in exact contact and the union portion is fastened firmly with polythene tape (100 gauge). The scion portion on the stock is covered with polythene bag to ensure the humid condition also to overcome the desiccation of the scion. Alternatively, all the grafted plants can be kept under poly house with mist facility to ensure the hot humid conditions required for faster callus growth in the joint region. The plants are maintained under nursery shed for 20-30 days to encourage the sprouting of the potential buds on the scion portion after which the polythene bags are removed and the grafts are shifted to shade-net house (50%) and then to open condition for hardening. Depending on the season, about 70-

Longitudinal cleft in root stocks

Placing of wedged scion in cleft

Tying of graft joint

Grafted plant

Covering of scion with polythene bag

Fig. 10. Preparation of root stock and tieing of graft

90 per cent graft success can be achieved by this method.

A. 4. After care: Polythene strip should be removed after five months to avoid girdling on graft union. The side shoots arising from the root stock region should be removed periodically. Striking of the tap root in to the nursery ground can be prevented by stacking the successful grafts on polythene sheet spread on the nursery ground. This also helps in sorting of the week grafts for special care. Grafts should be watered regularly depending on the season. Fungal diseases on young leaves can be controlled by spraying the Grafts should be sprayed with Bavistin (1%) to mangage fungal diseases on young leaves and with monocrotophos (1.5ml/litre of water) against sucking pests and leaf minor, at 15-20 days interval. Flowering, if any, in the grafts in the nursery should also be removed.

***B. In Situ* Grafting :** In this method of propagation also, softwood grafting technique is employed, but he the entire exercise is carried out in the main field itself instead of the nursery practice. Various steps involved are:

- Lay out the main field and dig-open the pits for curing during May. Fill the pits with top soil mixed Farm yard manure (FYM).
- Plant 2-3 selected seeds in the first week of June, in the centre of each pit filled with soil and FYM to raise the root stocks in the main field.
- Graft the desired pre-cured scion as described in 'soft wood grafting' on 3-4 months old, healthy root stock seedlings during September-October period and cover the scion with plastic cover. Other seedlings can be used if graft take is failed in the first attempt.
- Once the buds are sprouted, remove the plastic bag and remove the plastic strip January or February to avoid girdling. Remove the side shoot on the root stock below the grafting union.

Advantages: Tap root system is intact unlike in field planted grafts, therefore, supports the extensive growth of lateral roots and withstands the onslaught of uprooting by stormy winds.

In situ grafting may induce precocity, because, minimum size of canopy required for first harvesting is achieved in advance of one year.

If root stocks are standardized, this method offers scope for taking advantage of positive stionic effect for specific varieties.

In situ grafting is cost effective.

C. Top working: This is a technique exclusively for rejuvenating / converting the unproductive cashew trees into trees of high yielding varieties. Poor yielding young trees of 5-20 years age can be top worked with desired high yielding variety. This technique involves the following steps:

Fig. 11 . *In Situ* grafting :

A - Germinating seeds in pit in the main field
B - Seedlings ready for *in situ* grafting after 4 - 5 months
C - Healthy *in situ* soft wood graft
D - Canopy growth of *in situ* graft

- Selection of trees. Poor yielding trees from existing plantations have to be identified for top working.
- Beheading: The selected tree have to beheaded to a height of 0.75-1.0m from the ground level with the help of saw to overcome the cracking or splitting at the cut ends. Beheading has to done during may-August.
- Spray the cut ends with Chlorpyriphos (0.5%) and apply Bordeaux Paste(10%) immediately to overcome the attack of cashew stem and root borer.
- Lateral buds from the sides the beheaded branches start sprouting within a month resulting in lot of new shoots which need to be protected from the attack of tea mosquito bug and other insects.
- Grafting: Scions of the desired high yielding varieties have to be wedge-grafted on the soft wood region of the young shoots sprouted from the sides of the cut branches. Grafting has to be done on 10-15 healthy shoots of 30-45 days growth during August-October. Other shoots should be thinned out to encourage the graft take.
- Side shoots arising from the portion below the graft union should be regularly removed.

  In successfully top-worked trees, growth of canopy would be very fast because of the advantage of its well established root system and the trees start yielding right from second year itself.

D. Air layering: This is the earlier method which was being followed before the soft wood grafting was standardized in cashew. In this method, the mature shoots on the tree are girdled and the girdled region is fastened with moist growth medium to facilitate the rooting at the girdled region. Once sufficient rooting is observed after three months, the shoots with roots are cut from the tree for using as true to type planting material. This method has become obsolete now for cashew.

5

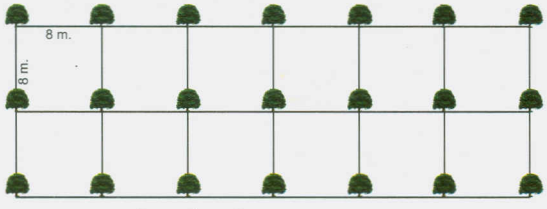
PREPARATION OF LAND AND PLANTING

For establishing new orchards, the land has to be cleared off thorny bushes, shrubs and other weeds well before the pre-monsoon showers (April May).

5.1 Planting Systems for lay out: Selection of appropriate planting system based on the topography of the land, fertility and type of soil is very important for establishing cashew plantations in different locations. Generally, Square, Rectangular and Triangular System of planting are recommended for cashew plantations.

1.Square system: Spacing between rows and columns of trees is same. Spacing of each tree in all the four directions is same. Recommended spacing s are : 8m X 8m for highly fertile soils, 7m X 7m for medium and light soils and 5m X 5m (high density planting) for sandy or poor or very light soils

Type of soil	Spacing	No. trees/ha.
Fertile soils	8m X 8m	156
Medium and light soils, Red laterite soils	7m X 7m	204
Poor/ sandy/ lighter soils	5m X 5m (High Density)	400



Sketch of square system

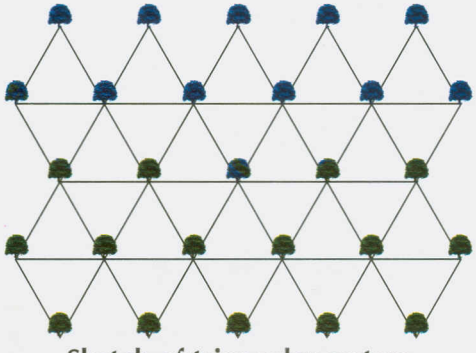
2. Rectangular System: Spacing between rows and columns of trees is different depending on the purpose and topography of the land.

Type of soil	Spacing	No. trees/ha.
Fertile soils	9m X 7m	158
Medium and light soils, Red laterite soils	8m X 6m	208
Poor/ sandy/ lighter soils	5.5m X4.5m (High Density)	404

Sketch of rectangular system

3.Triangular System: In this system, the spacing of all the trees will be equidistant in six directions and three trees are arranged in triangular manner. This accommodates 15 % more population compared to square or rectangular system.

Type of soil	Spacing	No. trees/ha.
Fertile soils	8m X 8m	180
Medium and light soils, Red laterite soils	7m X 7m	234
Poor/ sandy/ lighter soils	5.25m X525m (High Density)	416



Sketch of triangular system

Lay out the field in appropriate system with peg marking at recommended spacing to facilitate digging of pits.

5.2 Opening of pits: Pits of the size of 60 cm X 60 cm X 60 cm at the required spacing depending on the planting system can be opened manually. Circular pits of 60cm (24") diameter with 60 cm depth can be opened mechanically also by tractor mounted post hole digger. Leave the pits open for about 15-20 days for curing.

5.3 Planting material and method of planting:

Healthy, 10-12 months old soft wood grafts of improved high yielding varieties should be used for planting. After pre-curing, fill pits completely with top soil mixed thoroughly with one basket (15-20 kg) of compost or Farm Yard Manure, 300-400 g massoriephos or rock phosphate and 100 g of anti termite pesticide. For planting, scoop out a spadeful of top soil from the centre of the pit. Graft has to be placed in the pit in such a way that graft joint is 5 cm. above the ground level. Support the graft with appropriate staking by tieing loosely with gunny thread.

5.4 Time of planting: Immediately after the onset of monsoon, plant the graft in the center of each pit and support it with appropriate staking. Mulching the basin with green leaves helps establishment of the grafts. The most ideal time for planting of cashew grafts is second fortnight of June to July. Planting during this period ensures better establishment of grafts in the field. In case of *in situ* grafting, planting of selected seed nuts has to be done in the centre of pits, as described earlier, in the first week of June just after the on-set of monsoon.

Sun-cured pit ready for taking up planting

Removal of polythene bag before planting

Graft with intact earth ball placed in centre of the pit

Support of staking for graft

Fig. 12 Method of planting graft

6 HIGH DENSITY PLANTING

In order to use the land intensively for realising higher productivity per unit area, especially in the early phase of the plantation and also to achieve the higher economic returns in the early phase, high desity planting techniques can be adopted (Salam, 1997). This also can be followed where the soil fertility is poor for which the canopy expansion will not fast. This method involves planting of more number of grafts per unit area as compared to that of normal density of 200 number of grafts at 7m X 7m spacing. In order to achieve higher density, grafts are planted at 4mx4m, 5mx5m or 8mx4m for the planting density of 625, 400 or 312 per hectare, considering the suitability, purpose and need. Depending on the type land, higher density population is retained for the initial period 7-10 years. This actually is based on the rate at which the canopy is expanding in orchard conditions. In poor soils, rate of growth will rather slow and hence population density can be maintained for longer period till the cnopies of the adjoining trees touch with one another. On the other hand, in fertile soils canopy expansion will be faster indicating the early thinning of population to overcome competition among the trees for soil moisture, nutrients and light. Finally, at full growth stage, population is reduced to normal density of 200 trees by thinning down the population periodically.

This is a specialized technique, which needs intensive management of nutrient supply, canopy pruning and irrigation practices with view to maintain sustainability in the long run. Studies have indicated that cashew yield can be increase to three to four folds in the initial phase up to 6-7 years which would further decline gradually up to two fold at 12^{th} year in a plantation with density of 312 to 625 trees per hectare as compared to plantation of normal density of 200 trees per hectare (Venkattakumar et al,2003 Jose Mathew and Mini, 2008). This system also overcomes exposure of ground to the sunlight , especially in the peak summer and thereby decreasing the soil moisture evaporation. Heavy deposit of leaf biomass on the ground also conserves moisture and also adds in situ-recycled nutrients to the soil. There will also be reduced under canopy weed growth. Due to pruning and thinning , substantial quantities of fire wood can be obtained. One should be careful regarding the incidence of cashew stem and root borer and its integrated management while resorting to the pruning or thinning of trees.

7 MANURES AND FERTILIZERS

Most of the cashew growing areas in the country including that Goa state are poor soil fertility and water holding capacity. But, the studies have indicated that Cashew responds well to application of manures and fertilizers. The standard recommended dose and schedule of application for cashew trees of different age groups are as given in table 2.

7.1. Method of Applying: Entire quantity of manure or compost and half of the recommended dose can be applied in the first fortnight of June and remaining half in August-September. Fertilizer has to be applied in a circular ring within a radius of 22.5 m around the tree trunk at a depth of 15 cm and covered with green leaves and soil. In hill plantations to avoid leaching, entire dose can be applied once in August. Problematic soils (reclaimed mine rejects of Goa) need to be tested. Special care needs to be given while recommending for High density plantations to avoid excess application per unit area.

7.2 Management of soil pH: Most of cashew growing coastal areas being high rainfall areas, generally soils are lateritic and acidic in nature. Since very low pH conditions are not conducive for better performance of cashew, such soils, observed, particularly in Goa, can be ameliorated by application of 5-10 kg of lime or dolomite per tree once in two to three years. This practice facilitates the availability and uptake of nutrients especially phosphorous, calcium, magnesium and micronutrients like molybdenum by the trees.

Of late, customized speciality fertilizers are coming into the markets in a big way. These are specific to the crops and location. Such speciality fertilizers for cashew crop would be of utmost importance from precision farming point of view in order to avoid under or over- use of fertilizers. These are also taking care of the requirement of cashew trees for micronutrients, which otherwise, are hardly given attention in commercial cultivation of cashew crop.

Organic cashew : Supplementing nutrients through organic sources like oil cakes, green leaf compost, vermicompost, fish meal, bone meal, FYM and Poultry / pig manure, spray of EMO, etc is a common practice for production of cashew organically. One should be careful while using oil cakes like neem cakes, as such cakes will cause the increase in soil acidity as a result of which multiple problems crop up in cashew plantations.

Table. 2. Recommended dose of manures and fertilizers

Age		Nutrients (g /tree/year)			Fertilizers (g /tree/year)		
	Compost / FYM (kg)	N	P_2O_5	K_2O	Urea	Rock phosphate	Muriate of potash
1	15	250	50	50	250	175	85
2	30	500	100	100	500	350	165
3	40	750	200	200	1000	750	330
4th yr & onwards	50 kg	1000	300	400	2000	1500	660

8 INTERCROPPING

During the initial period of cashew plantations, several intercrops can be taken up in the inter-space up to first three-four years. Considering the terrain of the land under agro-climatic conditions of Goa, high value crops such as turmeric, ginger, groundnut, vegetables like bhendi, cucurbits, chillies and fruit crops like pine-apple, papaya can be taken up. This practice not only provides considerable income from intercrops, even will have complementary beneficial effects on cashew grafts during the initial period of growth and development, besides providing employment opportunities, during the gestation period.

Studies have indicated that turmeric varieties such as Sudarshan, Prabha, Pratibha, Kedaram, Alleppey and RCT-1, and ginger variety- Varada can be successfully cultivated as intercrops in cashew plantations during gestation period with rhizome yield of 10 12.5 tonnes per hectare to realize a net profit of Rs 50,000 from one hectare area. Similarly, Confectionary type of groundnut varieties like Asha and TPG-40 can also be successfully cultivated as intercrop in cashew plantations for considerable income.

For planting of Pineapple trenches of 1m width and convenient length should be opened across the slope in the interspace. Pineapple suckers are planted in paired rows, 60cm apart with 30cm spacing between plants , in zig zag manner. Improved varieties like Queen, Gaint Kew and Mauritius can be taken up. About 15 tonnes/ha of fruit yield can be harvested from the interspace. Drumstick (which can serve as trap crop against TMB) with proper pruning can also be taken up along the contours.

9 SOIL AND WATER CONSERVATION MEASURES

Continuous contour trenches (CCT) of field length or 2m long Staggered contour trenches of 45cm top width X 30 cm bottom width X 45 cm depth (SCT) are recommended for *in situ* moisture and soil conservation measures (Manivannan, 2003). This practice will greatly support the establishment of grafts in the main field and also the grown up trees especially during dry period coinciding with flowering and fruit setting period. Studies on young cashew trees of 7 years old plantations at our institute indicated that such practices would enhance physiological efficiency of the trees and thereby increase the yield by more than 50 per cent (Desai, 2008).

Fig. 13. Inter cropping in cashew : A - Turmeric, B - Ginger, C - Elephant foot yam

10 TRAINING AND PRUNING

During the initial stage of orchard establishment, shoots arising on the rootstock have to be regularly removed to promote better scion growth, particularly in the first year after planting, which otherwise could result in scion rejection thereby leading to the field mortality of grafts. Since cashew trees tend to spread their canopies and lodge easily, proper staking is also essential. Training of young trees during the first three years is essential to develop uniform canopies. Training in the juvenile phase basically comprises of removing basal branches and water shoots. The plants are trained to a single stem and branches are allowed to grow about 0.75-1m from ground level. Deformed branches are also removed during the first few years. Trees are kept under check by topping off the main stem at a height of 4-5m from ground level. Orchard operations such as terracing, weeding, fertilizer application, nut collection and stem/root borer infestation control can be easily achieved if trees are properly trained.

Pruning should be carried out in August-September at least once in three years in order to remove the crisscrossing branches and unwanted growth for providing the incidence of adequate sunlight into the canopy. Since fruiting is only encouraged from the third year, de-blossoming has to be carried out as flower clusters appear during the initial phase of growth. Dead branches and branches with die-back symptoms should also be pruned periodically. Depending on the growth habit of the trees of different cashew varieties, the canopies of the neighbouring trees will start touching each other after 7-10 years of age. Regular, light pruning of the branches all around the canopy will facilitate the exposure of canopy to sunlight. Studies at Directorate of cashew Research, Puttur, have indicated that pruning enhances flowering and yield in varieties with extensive branching habit, while it will have adverse effect on varieties with intensive branching habit. Yield stabilization can be achieved after 7-8 years of planting. Therefore, pruning should be selective, variety specific and in old trees which have tendency for declined yield (Nayak, 2007).

Limb pruning technique can be used as a good tool to rejuvenate unproductive plantations of improved varieties /hybrids of cashew Trees of more 15years,which cover entire inter and intra space and show decline in yield or fail to give yield (Rajanna and Nayak, 2007). This technique involves cutting of the primary branches at 2 ½ -3 feet from the main trunk during August-September so that, new sprouts commence in the next month which subsequently flower and fruit in January-February. Pruning has to be done by using a saw to achieve a perfect cut end without any cracks or damage to the bark of the branch. This technique has given successful results for cashew trees cultivated in fertile soils of planes in Karnataka.

11 PLANT PROTECTION

On cashew, major insect pests are Tea mosquito bug (*Helopeltis antonii* S.) and Cashew stem and root borer (*Plocaederus ferruginneus* L.), besides which other insects like leaf and flower webber, thrips, leaf minor and mealy bugs, considered as minor pests, are also causing economic loss in cashew crop of late.

11.1. Tea mosquito bug (TMB) : Incidence of Tea mosquito bug on cashew occurs at new flushing, flowering and fruiting stages during September to April and causes crop losses ranging from 20-60 per cent. The damage is caused by adult bugs as well as by immature stages (nymphs) which suck the plant sap from the tender flushes and succulent shoots, flower panicles, growing nuts and apples.

Symptoms: Closer observation reveals the occurrence of dark brown patches on green tender stem of young shoots and inflorescence rachis. Severe incidence leads to flower blight and drying of young shoots and flower panicles. Attack on tender nuts and apples causes shriveling of developing nuts leading to immature fruit drop. The affected trees will conspicuously have the dried leaves on dead tender shoots and dried inflorescences on tree canopy which can be prominently seen from a distance. Severely affected branches may lead to the secondary infection by fungus *Botrydiplodia theobromae*) causing 'die back' disease, i.e drying of branches from tip and extending downwards. Such branches will have the brown discolouration in the sap wood extending towards lower portion.

Integrated Management: This pest can be effectively managed by spraying the trees in three critical stages.

1. Establish the cashew plantation by planting 2-3 high yielding varieties with varied degrees of tolerance or escape mechanism so that the impact of pest incidence will be reduced due to varied degree of pest host reaction.
2. Spray the tree canopy at flushing stage with monocrotophos at the rate of 1.5 ml/ litre of water (0.05%) or with Lambda-cyhalothrin at the rate of (0.003%)
3. Spray carbaryl (50% WP) at the rate of 2g/litre of water (0.1%) or chlorpyriphos (0.05%) at flowering stage
4. Repeat the 'first spray' at initial fruiting stage.
5. Cut the 'die back' affected branches up to the healthy region and apply the cut end with Bordeaux paste (10%) and spray the tree with 1 per cent Bordeaux mixture solution.
6. Arrest the build- up of the pest population by maintaining the hygienity in plantation and also care should be taken for controlling the population even on the alternate host trees (drum stick, guava, neem, etc ., if any, in the surroundings.

11.2. Cashew stem and root borer (CSRB): This is the most dreaded pest of cashew trees, the immature stages (grubs) of which feed on the bark of trunk and roots and out rightly kill the tree within few days. Due its concealed nature of damage, it is difficult to make out the status or level of damage to the tree and therefore, unlike

TMB, is a threat to the life of the tree. This is a dark brown beetle with long antennae which lays eggs in the crevices of the bark on the collar region.

Symptoms: Incidence of the pest can be made out by the presence of extruded frass (like coarse saw dust powder) on the ground surface at the base of cashew tree trunk. On closer examination, one can see small holes on the collar region through which the frass is pushed out by the insect. After hatching of eggs, the grubs immediately start boring into bark of collar portion and root for feeding on the inner portion of the bark tissues. Further, they bore irregular tunnels throughout. As a result of severe injury to the vascular bundles, gum like substance oozes out and gets deposited on hardening to form dark brown clumps on the affected region. In case of severe infestation , due to continuous feeding on vascular tissues, the trunk becomes internally girdled. At this stage, leaves show yellowing symptoms, start shedding immaturely and subsequently the entire tree dries up within a few days. Affected trees also tilt on one side due to loss of anchorage, if the injury is severe on anchoring roots. Infestation occurs round the year.

Integrated management:

1. Monitor regularly for the presence of the frass near the base of the trunk.

2. Mechanically remove the grubs from infected trees in the initial stage of infestation.

3. inject 0.36 per cent monocrotophos by the padding method.

. Soak / drench the bark of the infested trees with 0.5L of 0.1 per cent chlorpyriphos, one meter above the ground and also by drenching the soil/ root zone in a radius of 0.5m around the stem with 5L of the same insecticide to kill the grubs / pupae in the root zone.

5. Repeat the injection of all infested trees with monocrotophos after 15 -20 days.

6. It is very important to adopt the phytosanitory measures like removal of dead trees infested with CSRB and bury or burn the same to avoid further spread of infestation.

11.3. Minor pests:

Leaf and blossom webber (*Lamida moncusalis* L.): As indicated by its name, this pest attacks the young leaves of new flush and inflorescences. The caterpillars form the web of young leaves and flower panicles and feed on these from inside as a result of which, the webbed shoots totally dry up.

Leaf miner (*Acrocercops syngramma* M.): Larvae of this insect mine through the young leaves of new flushes. In the mined laminal areas the epidermal layer gets separated from the leaf tissues in patches giving white blistered patches.

Apple and nut borer (*Thylocoptila* sp.): The larvae of this pest bore the region of juncture where the nut is attached to apple and start feeding on tissues. The incidence can be conspicuously seen by the presence of frass and excreta of the larvae at the tunneled place.

Mealy bug (*Ferrisia virgata*): Nymphs and adults of mealy bugs suck large amount of sap from the growing shoots, inflorescence and developing fruits. These insects also excrete sugary substance (honeydew) on which sooty mould develops which impairs photosynthetic activity rendering 16-30% losses in nut yield under severe out break conditions.

All these minor pests can be taken care of by the prophylactic sprays adopted for the management of tea mosquito bug.

Fig. 14. Tea Mosquito Bug: a serious pest on cashew

A - Adult bug
B - Immature stage (Nymph)
C - Shoot damage

Fig. 15. Damage by cashew stem and root borer

A - Dried tree affected by cashew stem and root borer

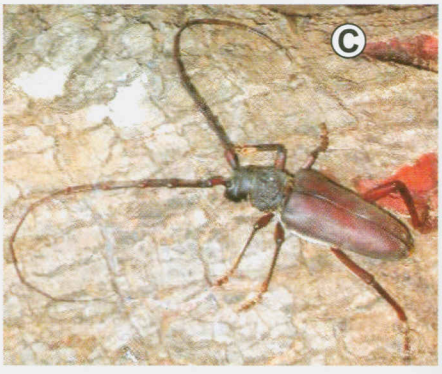
B - Immature stage (Grub) of cashew stem and root borer

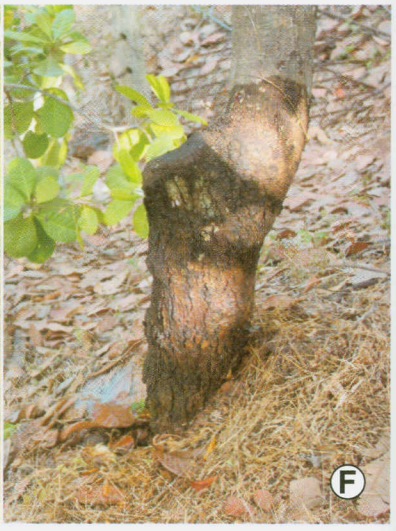
C - Adult of cashew stem and root borer

D - Frass near the affected trunk

E - Drenching of chlorpyriphos on base on the trunk

F - Recovered turnk





12 HARVESTING AND YIELD

It is advisable to take crop from fourth year onwards, before which flowers, if any, may be removed to encourage proper vegetative growth. The harvesting, depending on the varieties, commences from February and continues till May end. In Goa, the dropped fruits with nuts are collected and nuts are separated from the apples. General yield trend of improved varieties is presented below.

About 10 15 kg per tree (2.5 - 3 tonnes/ha) of raw nut yield and about 80 100 kg per tree (1520 tonnes/ ha.) of cashew apple yield may be expected at 10th year and onwards, with adoption of all the production practices on time. Nuts separated from apples are thoroughly sun-dried for 3-4 days and stored in gunny bags for further processing.

Table 3. Expected yield performance

Age of tree	Nut yield (Kg /tree)	Apple yield (Kg/tree)	Yield per ha*. (tonnes)	
			nut	apple
4th year	0.7	5.0	0.15	1.0
5th ,,	1.5	10.0	0.3	2.0
6th ,,	3.0	20.0	0.6	4.0
7th ,,	6.0	40.0	1.2	8.0
8th ,,	8.0	60.0	1.6	10.0
9th ,,	10.0	70.0	2.0	15.0
10th ,,	12 - 15	85.0 - 100.0	2.5-3.0	17.0 -20.0

*200 grafts/ ha (7m X 7m spacing)

13 ECONOMIC RETURNS

For establishing cashew plantation in one hectare area, it requires about Rs 27100.0 for initial investment. But, cashew has a juvenile phase for the initial period 3-4 years. During this period, considering the need and suitability, high value annual crops can be cultivated as intercrops for deriving the income during the juvenile period. Economic yield can be harvested from fourth year after planting and the breakeven point starts from 6^{th} - 7^{th} year. Details of cost of cultivation and economic returns from cashew plantation of one hectare area for first ten years are presented in Table 4. With all the improved production practices and stabilized yield at 9-10 years , a net return of more than Rs 80 000 may be expected annually from one hectare area under cashew plantation.

Table 4 . Cost of cultivation for establishment of 1 ha of cashew plantation with density of 200 tree/ha (7m X 7m spacing) and economic returns:

Particulars	I yr	II yr	III yr	IV yr	V yr	VI yr	VII yr	VIII yr	IX yr	X yr	Total
Land clearing 30 man days X Rs 200	6000	1000									7000
Digging of 200 pits @ 25	5000										5000
Pit filling, planting , staking & mulching @ Rs. 5	1000	200									1200
Cost of grafts (210 no) @ Rs 25	5000	250									5250
Organic manure @ Rs. 0.5 X 15kg X 200	1500	3000	4000	5000	5000	5000	6000	6000	6000	6000	47500
Chemical fertilzer	600	1200	2000	3000	4000	6000	10500	12000	12000	15000	66300
Plant protection	250	500	750	1000	1250	1500	2000	2250	2500	2500	14500
Labour for fertilizer application	500	750	1200	1600	2000	2000	2000	2000	2000	2000	16050
Labour for Plant protection	250	480	900	1200	1200	1500	1500	1500	1500	1500	11530
Implements	1800					2000					3800
Intercrops (Rs/ha)	4000	4000	3000	2000							13000
Labour(Harvesting) @Rs 2/kg				200	400	1000	2000	3000	4000	5000	15600
Miscellaneous(Rs/ha)	1200	1200	1200	1200	1500	1500	1500	1500	1500	1500	13800

Table 4 Contd...

Total Expenditure	**27100**	**12580**	**13050**	**15200**	**15350**	**20500**	**25500**	**28250**	**29500**	**33500**	**220530**
Cash Flow											
From intercrops	15000	12000	12000	6000	-	-	-	-	-	-	45000
Nut yield(kg/ha)	-	-	-	150	300	600	1200	1600	1800	2000	
Income from nuts(@Rs 50/kg nuts)				7500	15000	30000	60000	80000	90000	100000	490000
Apple yield (kg/ha)	-	-	-	1000	1400	3500	7000	10000	15000	17000	
income from apple @Rs 1/kg apple)				1000	2000	4000	8000	10000	15000	17000	55600
Total gross returns	15000	12000	12000	14500	17000	34000	68000	90000	105000	117000	362600
Net Total Returns (Rs)	-12100	-580	-1050	-700	1650	13500	42500	61750	75500	83500	159270
Net return per tree(Rs)					6.75	67.5	212.0	308.75	377.5	417.0	

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