Cashew Production and Post Harvest Technologies

Edited by:
Dr. Eradasappa.E
Dr. B.Venkata Rao
Dr. Aswathy Chandrakumar

Cashew Production and Post-Harvest Technologies

Edited by: Dr. Eradasappa, E., Dr. B Venkat Rao and Dr. Aswathy Chandrakumar

Edition: 2022. All rights reserved.

ISBN: 978-93-91668-71-6

Citation: Eradasappa, E., Venkat Rao, B. and Aswathy Chandrakumar (2022). Cashew Production and Post-Harvest Technologies. Hyderabad: National Institute of Agricultural Extension Management (MANAGE), Hyderabad & ICAR-Directorate of Cashew Research, Puttur, Karnataka, India.

Published for Dr.P. Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

Cashew Production and Post Harvest Technologies, 16-18 February 2022

ICAR-DCR Puttur and MANAGE

List of Resource Persons and Their Affiliations

Conservation and Utilization of Cashew Genetic Resources

Mohana, G.S.* and Eradasappa, E.

ICAR- Directorate of Cashew Research, Puttur, Karnataka
*for correspondence: mohangs2007@gmail.com

Introduction:

Cashew (*Anacardium occidentale* L.) belongs to the family *Anacardiaceae* and is a native of Brazil. The family comprises of about 60 genera and 400 species of trees and shrubs with resinous bark, and grows most abundantly in the tropics in both eastern and western hemisphere (Ohler, 1979). Several other important fruits and nuts such as mango (*Mangifera indica* L.), the Pistachio nut (*Pistacia vera* L.) and various speices of *Spondias* such as Otaheitc apple (*S. cytherea*), Hog-Plum (*S. mombin*) and Spanish plum or red mombin (*S. purpurea* L.) belong to this family. According to Baily (1949), the genus *Anacardium* contains eight tropical American species. Parente (1972) names 10 species but Peixoto (1960) names twenty different species several of which had edible peduncles such as *A. nanum*, St. Halaire, a very early bearing small shrub, *A. subterranium* Liais, a small shrub with its trunk almost completely underground containing water reserves; *A. microcarpum* Ducke, a small tree from sandy savannas, *A. spruceanum* Benth. a large tree and the largest species of the genus *A. giganteum* Hancock which grows in Amazon forest. However, as per the latest working list of all plant species, the *Anacardium* genus comprises of 20 species (Anonymous, 2010).

The cultivated species *A. occidentale* L. is andromonoecious, with male and hermophrodite flowers in the same inflorescence and the phenomenon is almost similar in all the species of the genus *Anacardium* (Damodaran, 1977). Within the species *A. occidentale* also, there is a wide variation in colour, size and shape of the apple, as well as in size and shape of the nuts. The time of flushing, flowering varies among different types. There are also differences in leaf size and leaf shape and numerous other characters.

Origin and distribution:

Brazil is the original home of cashew. The earliest reports of cashew are coming from French, Portuguese and Dutch observers (Johnson, 1973). The presence of cashew in other continents is to be attributed to man's intervention. The Portuguese discovered cashew in Brazil and spread first to Mozambique (Africa) and later into India (De Castro, 1994).

Cashew was introduced to India by Portuguese during 16th century. Molecular studies have shown the possibility of its introduction repeatedly over a period of time but at a single location i.e. west coast (Archak, *et al,* 2009). 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 Chhattisgarh, Gujarat, Assam, Arunachal Pradesh, Meghalaya, Tripura, Manipur, Nagaland and Andaman and Nicobar Islands (Singh, 1998). After the establishment of National Research Centre for Cashew (NRCC) at Puttur, Karnataka in 1986 (upgraded to Directorate of Cashew Research in 2009), the germplasm collection through vegetatively propagated material started and since then, a coordinated approach was brought in the cashew germplasm collection by organizing joint survey teams consisting of scientists of NRCC and the centers of All India Coordinated Research Project on Cashew (AICRP on Cashew) of the respective 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, Jharkhand, Orissa and West Bengal. The non-traditional areas such as Garo Hills (Meghalaya), Bastar (Chhattisgarh), Gujarat, Dadra & Nagar Haveli and Andaman & Nicobar Islands were also surveyed for germplasm collection. So far, 542 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 Centers which are maintaining a total of 1726 accessions.

Efforts of conservation and utilization at the ICAR-Directorate of Cashew Research, Puttur, Karnataka

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. 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 characters following "Cashew Descriptors" (IBPGR, 1986). So far 506 clonal accessions out of 542 accessions have been evaluated and 478 are conserved in a conservation block by planting 4 plants per accessions at a closer spacing of 4 m x 4m.

The information on first set of 56 accessions planted in 1986 has published in the "Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-I", 1997. The second set of 97 accessions planted in 1987 and 1988 have been documented in the "Catalogue of Minimum Descriptors of Cashew Germplasm

Accessions-II", 1998. The third set of 102 accessions planted in 1989 and 1990 have been included in the "Catalogue of Minimum Descriptors of Cashew Germplasm Accessions-III, 2000. These are the first efforts made in characterisation of clonal accessions of cashew in the world where 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 1198-2003 have been published (Nayak *et al*, 2014; Nayak *et al*, 2015). The germplasm accessions which are unique and have potential (verified / verifiable) attributes of scientific/commercial value are registered in NBPGR, New Delhi

Development of cashew germplasm database management system

A robust Decision Support System (DSS) has been developed recently for cashew with 478 accessions and 68 characters to manage and better utilize the germplasm resources. In the module, it is possible to select accessions based on multiple character combinations with information such as frequency distribution, images and pie diagrams. This is expected to help all the stakeholders involved in cashew research, production and processing for selection and subsequent utilization of suitable germplasm accessions. The module can be accessed at https://cashew. icar.gov.in/dcr

Genetic Architecture of Cashew Germplasm

The variability and genetic architecture was assessed deploying 13 important quantitative characters of 478 cashew germplasm accessions evaluated and conserved in National Cashew Field Gene Bank, Directorate of Cashew Research, Puttur (Mohana *et al*, 2017). Considerable variability was observed for all characters (Table 1) and the highest CV was observed for sex ratio followed by cumulative yield per plant and apple weight. The lowest CV was observed for shelling percentage followed by shell thickness. Frequency distribution patterns showed highly positively skewed distribution for characters such as nut weight, sex ratio, apple weight and apple to nut ratio. Genetically, it is evident that decreasing alleles are in excess and dominant for these characters. Whereas tree spread, kernel weight and cumulative yield per plant showed moderately positively skewed distribution indicating decreasing alleles are in slight excess and dominant. Flowering intensity showed moderately negatively skewed distribution indicating the presence of increasing alleles in slight excess and their dominant nature. Tree height, shell thickness, flowering duration, shelling percentage and leaf area showed approximately symmetric distribution indicating increasing and decreasing alleles are in equal proportion and the dominance is ambi-directional.

Table 1: Descriptive statistics of 478 cashew germplasm accessions

Character	Range	Minimum	Maximum	Mean	SE of Mean	SD	CV (%)	Skewness	SE of Skewness	Kurtosis	SE of Kurtosis
Tree Height (m)	8.20	1.50	9.70	5.01	0.07	1.43	28.56	0.47	0.11	-0.22	0.22
Tree Spread (m)	9.60	1.50	11.10	6.20	0.07	1.57	25.30	0.72	0.11	0.36	0.22
Nut Weight (g)	14.78	2.00	16.78	6.88	0.10	2.09	30.41	1.02	0.11	1.91	0.22
Sex Ratio	0.29	0.01	0.30	0.09	0.00	0.05	52.21	1.08	0.11	1.76	0.22
Apple Weight (g)	170.00	10.00	180.00	61.82	1.07	23.37	37.81	1.10	0.11	2.45	0.22
Shell Thickness (mm)	3.20	1.50	4.70	3.06	0.02	0.52	16.83	0.36	0.11	0.68	0.22
Flowering Duration (days)	88.00	42.00	130.00	82.54	0.82	18.03	21.85	0.16	0.11	-0.78	0.22
Apple to Nut ratio	26.10	2.00	28.10	9.32	0.14	3.14	33.64	1.10	0.11	2.75	0.22
Shelling Percentage	27.30	15.30	42.60	28.50	0.20	4.32	15.15	-0.10	0.11	0.42	0.22
Kernel Weight (g)	4.00	0.40	4.40	1.94	0.03	0.55	28.30	0.79	0.11	1.49	0.22
Leaf Area (sq.m)	131.30	37.00	168.30	87.33	1.11	24.30	27.83	0.36	0.11	-0.36	0.22
Cumulative Yield per plant (kg)	27.24	0.29	27.53	10.49	0.24	5.16	49.19	0.88	0.11	0.49	0.22
Flowering Intensity (%)	82.50	14.30	96.80	65.78	0.73	16.06	24.42	-0.60	0.11	0.00	0.22

Significant positive correlations with cumulative yield per plant were observed for tree height, tree spread, sex ratio, flowering duration, apple to nut ratio, shelling percentage and leaf area and significant negative correlation for shell thickness. The present germplasm collection represents sufficient number of accessions for both quantitative and qualitative characters in desired direction (Table 2). However, based on the frequency distribution patterns, it is imperative to collect germplasm with dwarfness, less tree spread, high nut weight, apple weight and high yield.

Unique types in germplasm accessions:

The germplasm accessions conserved in the NCFGB at NRCC, 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. 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.

Development of Core Collections in cashew

As cashew is a perennial tree, it needs more land and other resources to maintain accessions. Conservation through seeds is not feasible because of cross-pollination. Tissue culture efforts to regenerate plants from mature explants are not successful. Therefore, efficient management of the field gene bank particularly utilization requires designation of the core collection representing the spectrum of diversity present in the entire collection. A relatively new technique, the advanced M strategy with heuristic approach was deployed to develop the core collection in cashew (Mohana and Nayak, 2018). Sixty-eight morphometric characters of 478 accessions were subjected to analysis resulting in the core collection of 49 accessions. Further, another core collection of same number was constituted by K-Means clustering to compare the efficiency of two approaches. The validation parameters like mean difference, variance difference, coincidence rate, variable rate and class coverage among others were employed for comparative analysis. The results of these parameters revealed that the core collection designated by heuristic approach was better able to efficiently represent and retain the diversity of the entire collection compared with the core identified by clustering approach. The core collection block is already established and future conservation and breeding efforts will be focused on this cashew core collection.

Table 2: Number of cashew accessions for desirable quantitative characters

Character	No.of accessions	Top accessions (character values in parenthesis)
Tree Height (< 2.5 m)	5	NRC 153 (1.5), NRC 128(2.3), NRC 131 (2.4), NRC 100(2.5), NRC 239 (2.5)
Tree Spread (<3.0 m)	4	NRC 153 (1.5), NRC 121(2.5), NRC 131(2.7), NRC 190(3.0)
Leaf Area (> 120 sq.m)	50	NRC 270(168.3), NRC 291(159.0), NRC 279(156.0), NRC 277(152.0), NRC 278(150.3)
Nut Weight (> 7.0 g)	190	NRC 269(16.78), NRC 183 (15.4), NRC 161(15.0), NRC 402(14.2), NRC 383(13.4)
Sex Ratio (> 0.13)	74	NRC 60 (0.30), NRC 63 (0.29), NRC 68(0.27), NRC 279 (0.27), NRC 278(0.25)
Weight of Cashew Apple (> 52 g)	306	NRC 385(180.0), NRC 301(169.8),NRC 140(142.8), NRC 164 (141.0), NRC 333(135.0)
Weight of Cashew Apple (>100 g)	29	NRC 385(180.0), NRC 301(169.8),NRC 140(142.8), NRC 164 (141.0), NRC 333(135.0)
Shell Thickness (<2.5 mm)	40	NRC 152(1.5), NRC 153(1.5), NRC 285(1.5), NRC 87(1.7), NRC 281(1.8)
Shell Thickness (>4.0 mm)	16	NRC 160(4.7), NRC 278(4.6), NRC 166 (4.5), NRC 180(4.5), NRC 270(4.5)
Flowering Duration (<60 days)	50	NRC 266(42), NRC 246(47), NRC 238(48), NRC 265(48), NRC 221(50)
Flowering Duration (>90 days)	161	NRC 24(130), NRC 12(128), NRC 11(128), NRC 03(121), NRC 20(121)
Flowering Intensity (> 70 %)	205	NRC 126(96.8), NRC 175(95.5), NRC 141(95.2), NRC 148 (95.0), NRC 385 (93.7)
Apple to Nut Ratio (<6.0)	51	NRC 298(2.0), NRC 156(3.2), NRC 255(3.3), NRC 238(3.4), NRC 460(3.6)
Apple to Nut Ratio (>12)	74	NRC 41(28.1), NRC 385(18.9), NRC 370(18.6), NRC 115(18.5), NRC 327(18.1)
Shelling Percentage (>28 %)	265	NRC 406(42.6), NRC 343(41.0), NRC 393(40.5), NRC 405(40.5),NRC 327(40.3)
Kernel Weight (>2.5 g)	62	NRC 183(4.4), NRC 323(4.0), NRC 333(4.0) NRC 160(3.7), NRC 409(3.5)
Cumulative yield per plant (> 18 kg) –6 years	48	NRC 352 (Ullal- 1 ;27.53), NRC 457 (Estamol-1 ;26.82), NRC 349 (NDR-2-1 ; 26.21), NRC 356 (Chintamani-1;26.08), NRC 354 (Ullal-3 ; 25.95), NRC 465 (Banjha Kusum-1 ;24.96), NRC 346 (Vengurla-4;24.65), NRC 475 (Amritha; 24.42), NRC 452 (Anakkayam-1; 24.06), NRC 434 (Petamalapalli-1; 23.70)

Utilisation of germplasm:

Of the 28 cashew varieties and 14 hybrids released in the country, the varieties are *per se* selections made from the germplasm material at different centres. About 155 germplasm accessions have been effectively utilized for crossing programme at the Directorate of Cashew Research (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 research scheme "Network Programme on Hybridization in Cashew" which was in operation during 2000-2003. Leaf samples of 34 varieties and 153 germplasm 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, Madakkathara and Vengurla. The review of performance of varieties and hybrids indicated that in the States where both selections and hybrids were released for cultivation, the performance of hybrids has 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 and this is expected to provide impetus for cashew apple utilisation.

In the Directorate of Cashew Research, it was observed that when tall accessions are crossed with dwarf accessions, the majority of the resulting progenies have tall stature indicating that tall is dominant over dwarf character. In Madakkathara centre, when three parents with prolific bearing and three bold nut type parents were used for hybridisation, It was evident that wherever Brazil-18, an exotic bold nut accession was used in hybridisation, the percentage of high yielding progenies was more compared to other accessions within the country.

Diversity Analysis in cashew Germplasm through Molecular Markers

Moderate to high genetic diversity has been observed in germplasm collections in studies with RAPD markers (Anik *et al*, 2002). Further it was found that among RAPD, ISSR and AFLP markers, AFLP was found to have superior marker efficiency in differentiating germplasm accessions. A total of 172

accessions comprising collections from nine states of India and exotic sources were fingerprinted using both RAPD and ISSR markers (Thimmappaiah *et al*., 2009). Based on Shannon's information index and percentage of polymorphic loci, it is evident that high genetic variation was observed in the collections of Karnataka, Kerala and Andhra Pradesh. There was more diversity (96% variation) existed within the groups than between the collections (4% variation) from different states. Among the accessions NRC-432 and NRC-119 were highly divergent and NRC-235 and NRC-216 were highly similar. The cluster analysis performed to create dendrogram distinguished 17 clusters in all. Although there was no correspondence between the centre of collections and clusters, there were some exceptions as species from Brazil like *A. othonianum* and *A. pumilum* were found to cluster together in the same sub-group and some sub-clusters were in agreement with morphological clusters.

Similarly, genetic diversity and species relationship in 10 diverse types of cashew including three species (*Anacardium pumilum* St. Hillarie*, A. microcarpum* Ducke*, A. othonianum,* three inter-specific hybrids i.e. V-5 (*A. occidentale*) x *A. pumilum*, *A. pumilum* X V-5 (*A. occidentale*) and *A. orthonianum* X V-5 (*A. occidentale*) and four genotypes of *A. occidentale* was assessed using RAPD, Isozymes and SSR markers. In the cluster analysis three broad groupings were distinguished: In first group *Anacardium pumilum* was found clustering with two of its inter-specific hybrids, in the second group *Anacardium othonianum* clustered with one of its inter-specific hybrid and a dwarf accession Kodippady and while in the third group contained most accessions of *Anacardium occidentale* clustering with *Anacardium microcarpum* thus indicating close affinity between *A*. *occidentale* and of wild species *A. microcarpum*.

Future Areas of Work

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 and subsequent development of dwarf hybrids needs special mention since dwarf types are very much required for high density planting systems to improve productivity. Introduction of *A. gigantium* from Surinam which with biggest apple (200 g) will be advantageous, especially in states like Goa where the cashew apple utilization contributes substantially to the economy of the state.

One of the main problems in cashew is that all the existing germplasm are susceptible to CSRB which kills the trees. There is a need to screen the allied species (for their suitability as root stocks) which have relatively hard wood and also posses smooth bark. It is suggested that introduction of species like *A.*

rhinocarpus and *A. spruceanum* from Brazil which are reported to possess hard wood will be useful for testing their suitability as root stocks. However, more comprehensive exploration is required for target specific traits such as resistance to Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB), high yield, dwarf, bold nut with cluster bearing, tolerance to drought, frost, salt and other problematic soils etc.

Increased utilization of germplasm accessions in hybridization programs, exploitation of unique types such as CNSL free and rich types are some of the areas that need to be attempted in the ensuing days. Further, germplasm conservation through in vitro /cryopreservation needs attention as conserving in field gene bank requires considerable space and time. However, this requires in first place, the standardization of regeneration protocols for cashew which hitherto has not been successful. Pollen cryopreservation to conserve nuclear genetic diversity also needs to be tried in cashew as it is successful in some horticultural crops like mango, citrus, grape and papaya.

References

1. Anik Luke Dhanaraj, E.V.V. Bhaskara rao, K.R.M. Swamy, M.G. Bhat, D. Theertha Prasad and Suresh N. Sondur, 2002, Using RAPDs to assess the diversity in Indian cashew (*Anacardium occidentale* L.) germplasm. *The Journal of Horticultural Science & Biotechnology* 77(1): 41-47
2. Anonymous, 2010, The Plant List- A working list of all plant species http://www.theplantlist.org/browse/A/Anacardiaceae/Anacardium/
3. Archak, S., A. B. Gaikwad, K. R.M. Swamy and J. L. Karihaloo, 2009, Genetic analysis and historical perspective of cashew (*Anacardium occidentale* L.) introduction into India. *Genome*, 2009, 52(3): 222-230
4. Baily, L.H. (1949). Manual of cultivated plants. Mac Milan Co. New York (USA).
5. Bhaskara Rao, E.V.V. and K.R.M. Swamy (2000). Cashew Research Scenario in India. Indian Cashew Industry. Edited by H.P. Singh et al. Directorate of Cashewnut and Cocoa Development, Kohi-11. 30-41.
6. Damodaran, V.K. (1977). F_1 population variation in cashew. *Journal of Plantation Crops*. 5(2): 89-91.
7. De Castro,P. 1994. Summary of the study. In: .A M Delogu and G Haeuster (ed). *The World Cashew Economy* NOMISMA, L'Inchiostroblu, Bologna, Italy. pp. 11-12.
8. IBPGR, 1986, Cashew Descriptors. International Board for Plant Genetic Resources (Presently, Bioversity International), Rome.33pp.
9. Johnson, D. 1973. The botany, origin, and spread of the cashew *Anacardium occidentale* L. J. Plant. Crops. 1: 1-7.

10. G.S. Mohana, M.G. Nayak and E. Eradasappa, 2017, Genetic architecture of cashew germplasm accessions. *Journal of Plantation Crops* 45(1): 57-65

11. Mohana, G., & Nayak, M. G., 2018. Development of the core collection through advanced maximization strategy with heuristic approach in cashew (*Anacardium occidentale* L.). *Plant Genetic Resources: Characterization and Utilization*, 1-11. https://doi:10.1017/S1479262118000035
12. Nayak, MG, Mohana, GS, Bhat, PS , Saroj, PL and KRM Swamy, 2014, Minimum Descriptors of Cashew Germplasm Accessions, Catalogue –IV, Directorate of Cashew Research, Puttur. P. 32

13. Nayak MG, Mohana GS, Bhat PS, Saroj PL, KRM Swamy and MG Bhat, 2015, Minimum Descriptors of Cashew Germplasm Accessions, Catalogue –V, Directorate of Cashew Research, Puttur P. 44
14. Singh, H.P. (1998). Keynote address. National Seminar on Cashew Devlopment in India challenges and opportunities. Held at Goa on 1st and 2nd March 1998.

15. Swamy, K.R.M., Bhaskara Rao, E.V.V. and M.G. Bhat (1997). Catalogue of Minimum Descriptors of Cashew – Germplasm Accession-I. National Research Centre for Cashew, Puttur. pp.40.
16. Swamy, K.R.M., Bhaskara Rao, E.V.V. and M.G. Bhat. (1999). Catalogue of Minimum Descriptors of Cashew – Germplasm Accession-II. National Research Centre for Cashew, Puttur. pp.54

17. Swamy, K.R.M., Bhaskara Rao, E.V.V. and M.G. Bhat. (2000). Catalogue of Minimum Descriptors of Cashew – Germplasm Accession-III. National Research Centre for Cashew, Puttur. pp. 54.
18. Ohler, J.G. (1979). Cashew. Kohinklijk Instuut voor de Tropeu; Amsterdam. 50-78.
19. Peixoto, A. (1960). Caju. Servvico de In formacao Agaricola, Ministerio de Agricultura Rio de Joneiro (Brazil). 61p.

20. Parente, J.I.G. (1972). Cajueiro. Aspectos economicos e agronomicos. Circulara, instituto de Pesquisa Agropecuaria do Nordeste (Brazil) no. 19.

21. Thimmappaiah, Santhosh, W.G., Shobha, D., Melwyn, G.S., 2009. Assessment of genetic diversity in cashew germplasm using RAPD and ISSR markers. *Sci. Hortic,* 120, 411-417.

Popular cashew varieties in India

Eradasappa E* and Mohana, G.S.

ICAR- Directorate of Cashew Research, Darbe (P.O),

Puttur, Dakshina Kannada, Karnataka, India

*for correspondence:era.dasappa@gmail.com, eradasappa@icar.gov.in

Introduction

Cashew (*Anacardium occidentale* L) is a member of family Anacardiaceae which also has mango and pistachio. It 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 main product of cashew is nut containing a kernel. Cashew fruit also known as cashew apple and cashew nutshell liquid (CNSL) are the other products. The nut when processed gives the kernel which is the economic product because of its taste and nutritional value. The cashew apple has various uses; it can be eaten as fresh fruit, or processed into juice and other products like jam, jelly, cider, pickles etc. Feni, a popular liquor is produced from cashew apple in the state of Goa. CNSL oil is a by-product obtained during the processing of raw cashew nuts from the spent shells of the nuts and is used in friction linings, paints, varnishes and other industrial applications.

Although cashew is native to Brazil, it has spread to many tropical countries of the world. Top five cashew producing countries are Côte d'Ivoire, India, Vietnam, Cambodia and Nigeria (Sources: Global Cashew Council and International Dried Fruit Council, INC 2022). The major export markets for the kernel are USA, Europe, Canada, Japan and Australia. China is also emerging as a major market. India has become a largest consumer of cashews in the world and hence has potential domestic market.

The production of cashew in India 7.43 lakh tonnes from an area of 11.05 lakh ha with productivity of 672.4 kg / ha (FAO 2019). Whereas the requirement is 17 lakh tonnes per year. Thus there is shortfall of more than 50% in raw cashew nut production and hence India imports raw nuts from African countries. There is also threat for the import because nowadays African countries also thinking of processing cashew. 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. This kind of situation demands adoption of scientific strategies for increasing the domestic production in the light of declining import from cashew producing

countries due to various reasons. Cultivation of high yielding varieties is the most important step in improving the productivity of cashew.

Development of high yielding cashew varieties

So far 61 varieties in India have been released for cultivation as a result of evaluation of germplasm collection and hybridization and selection. These varieties have been released from different research centers of SAUs and DCR (formerly NRCC). Among them 34 are selections and 27 are hybrids (Table 1). Out of these varieties, salient features of popular varieties are presented below.

Varieties released from AICRP (Cashew) Center, Bapatla, Dr.YSR Horticultural Unioversity, West Godavari,

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 AICRP (Cashew) Center, Vridachalam, TNAU, Tamil Nadu

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 (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 AICRP (Cashew) Center, OUAT, Bhubaneshwar, Odisha

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 %).

Varieties released from AICRP (Cashew) Center, Jhargram, BCKV, Kalyani, West Bengal

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 7th harvest.

Varieties released from AICRP (Cashew) Center, Vengurla, KKV, Dapoli, 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-4 and Vengurla-7 are in great demand from farmers.

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-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-9

This is hybrid released in year 2015 in AGM -2015 of AICRP-Cashew. It is a cross between V-4 and VRI-1 (M10/4). It is middle to late season variety with 111 days of flowering duration and is bunch bearing variety with intensive branching. The nuts weight: is 8.9 g with 112 nuts per kg. It gives high yield (7.24 kg/tree) and has shelling percentage of 29.35%. The apple colour is reddish yellow and apple weight: is 69.71 g.

Varieties released from AICRP (Cashew) Center, ICAR-CCARI, 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 by AICRP (Cashew) Center, Madakkathara, KAU, Thrissur

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%.

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.

Varieties released from AHRS, Ullal, UAHS, Shivamogga, Karnataka

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-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.

Varieties released from ICAR-DCR, Puttur

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 outbreak 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.

Nethra Ganga

Nethra Ganga (H-130) is a jumbo nut hybrid, which yields 3 kg nuts / tree in 3rdyear of planting with cluster bearing (10-20 nuts/panicle), jumbo nut size (12-13 g) was released for west coast region. It is highly precious, early flowering type with long fruiting duration. It responds well to pruning and suitable for ultra-density planting system. The hybrid has high shelling percentage (29.9%) with big kernels (3.5- 5.0g) and kernel grade is W-130-150.

Nethra Vaaman

The country was hitherto lacking dwarfcashew genotypes and for the first time, the Directorate has identified a dwarf cashew variety named Nethra Vaaman. The dwarf genotype was selected from theseedling progenies planted out of importedbulk nuts samples of Brazil. Upon characterisation and evaluation, its slowgrowth and dwarf character was confirmed. This was evaluated for tenyears and recently it is released and recommended for cultivation. The Nethra Vaaman can be maintained with minimum pruning and trimming as an orchard management practice. The genotype is moderately susceptible to major pest of cashew i.e Tea Mosquito Bug (TMB) like any other cashew variety but it is easier to take up plant protection sprays as plants are dwarf. The variety seems to be also amenable for homestead and terrace gardens, and for bonsai cultivation. However, high yield cannot be expected because of its dwarf nature. Tree height (10^{th}year) is 2.5 m (dwarf). Tree Spread (10^{th}year) without pruning is 6.0 m. It has precocious flowering with long duration (>90 days). Nut weight is 5.5 to 6.0 g. It bears glossy, red colour, crispy and less fibrous cashew apples with 50 g weight. It has shelling percentage of 30% and the kernel grade is W 320. It shows special character of stem galling. Its nut yield is 1.2-1.5 kg (4^{th} year of planting).

Nethra Jumbo-1

Nethra Jumbo-1 is a jumbo nut hybrid released in 2021 for west coast region. Nethra Jumbo is an early season bearer with short flowering duration. The flowering starts from December and continues up to March and the peak flowering will be in January and February. The nut weight ranges from 11 to 13 g with an average nut weight of 12 g per nut. The nuts have high shelling percentage (29.1) with 3.66 cm nut length, 2.73 cm nut width and 2.41 cm nut thickness with 18.5 % of CNSL content in the shell. The kernels are bold with 3.4 g average weight and fits in to kernel grade W130. It bears attractive red coloured apples which weigh around 100g per apple with conical to obovate shape. The apples have TSS of 13 ◦ B with 72 per cent of juice content. The season of harvest starts from January and continues till March end. The duration of harvesting period is less which helps to save the labour on picking of nuts. The early availability of raw nuts will help to catch high market price prevailing during early part of cashew season. A ten-year-old tree has a potential to yield around 10 kg per tree. The added advantage of this hybrid is uniformity in nut size, wherein, more than 90 % of nuts are uniform in size. As this hybrid is an early flowering type, the advantage of higher market price

in the beginning of cashew season can be exploited. This hybrid can also escape severe pre monsoon moisture stress as compared to late varieties.

Varieties from HRS, Hogalagere (Earlier at Chintamani), UHS, Bagalkot

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%.

The state-wise varieties recommended are given below:

State	Recommended varieties
Karnataka	NRCC Sel-2, Bhaskara, Nethra Ganga (H-130), Nethra Vaaman, Nethra Jumbo-1, 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, Dhana , Vengurla-4, Vengurla-7
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, Vengurla-9
Goa	Goa-1, Goa-2, Goa-3, Goa-4, Vengurla-1, Vengurla-4, Vengurla-6, Vengurla-7, Vengurla-9
West Bengal	Jhargram-1, Bidan Jhargram-2, BPP-8
Orissa	Bhubaneswar-1, Balabhadra, Jagannath, BPP-8, Dhana
Tamil Nadu	VRI-3, VRI (Cw) 5
Andhra Pradesh	BPP-4, BPP-6, BPP-8 , , BPP-10, , BPP-11
Chattisgarh	Indira Kaju-1

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

S.No.	variety	Hybrid /selection	Year of release	Nut weight (g)	Kernel weight (g)	Shelling %	Yield (kg/tree)	Export grade	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
4	Nethra Ganga (H-130)	Hybrid	2018	12.9	3.5	29.5	3.0 (3^{rd} year)	W 180	Bold nuts, responds to pruning

5	Nethra Vaaman	Selection	2020	5.0	1.5	30.0	1.5	W 320	Dwarf, suitable for UHDP
6	Nethra Jumbo-1	Hybrid	2021	12.0	3.4	29.1	10.0	W 180	Early bearing, bold nuts
Cashew Research Station, Anakkayam, KAU, Thrissur									
7	Annakkayam-1	Selection	1982	5.9	1.67	28.0	12.0	W 280	Early, vigorous and short flowering period
8	Dharasree	Hybrid	1996	7.8	2.40	30.5	15.0	W 240	Mid season flowering, compact canopy
9	Akshaya	Hybrid	1998	11.0	3.12	28.4	11.0	W 180	Bold nut type
10	Anagha	Hybrid	1998	10.0	2.90	29.0	10.0	W 180	Bold nut type
Cashew Research Station, Madakkathara, KAU,Thrissur									
11	K-22-1	Selection	1987	6.2	1.60	26.5	13.2	W 280	Compact canopy
12	Madakkathara-1	Selection	1990	6.2	1.64	26.8	13.8	W 280	Early flowering, compact canopy
13	Madakkathara-2	Selection	1990	7.3	1.88	26.0	17.0	W 210	Late variety, high yield
14	Kanaka	Hybrid	1993	6.8	2.08	30.6	12.8	W 280	Mid season flowering
15	Dhana	Hybrid	1993	8.2	2.44	29.8	10.7	W 280	Mid season flowering and cluster bearing
16	Priyanka	Hybrid	1995	10.8	2.87	29.6	17.0	W 180	Bold nut, mid season and drought tolerant
17	Sulabha	Selection	1996	9.8	2.88	29.4	21.9	W 210	Mid season flowering
18	Amrutha	Hybrid	1998	7.2	2.24	31.6	18.4	W 210	Mid season flowering
19	Damodar	Hybrid	2002	8.2	2.00	27.3	13.7	W 240	---
20	Raghav	Hybrid	2002	9.2	2.27	26.6	14.7	W 210	--
21	Poornima	Hybrid	2006	7.8	2.60	31.0	14.1	W 210	

Agricultural Research Station, Ullal, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka									
22	Ullal -1	Selection	1984	6.7	2.05	30.7	16.0	W 210	Long duration, Escapes from the attack of TMB
23	Ullal -2	Selection	1984	6.0	1.83	30.5	9.0	W 320	Short duration, small nuts
24	Ullal -3	Selection	1993	7.0	2.10	30.0	14.7	W 210	Short duration
25	Ullal -3	Selection	1994	7.2	2.15	31.0	9.5	W 210	Short duration
Agricultural research station, Chintamani, UAS, Bengaluru, Karnataka									
26	Chintamani-1	Selection	1993	6.9	2.10	31.0	7.2	W 210	Uniform and attractive nuts
27	UN-50	Selection	1995	9.0	2.24	32.8	10.5	W 180	Bold nuts and high shelling percentage
28	Chintamani-2	Selection	2007	7.9	2.35	30.0	12.4	W 210	---
Cashew Research Station, Bapatla, Dr.YSR Hort Cultural University, West Godavari, Andhra Pradesh									
29	BPP-1	Hybrid	1980	5.0	1.37	27.5	10.0	W 400	Flush colour is pinkish, semi tall and cluster bearing
30	BPP-2	Hybrid	1980	4.0	1.04	25.7	11.0	W 450	Withdrawn from recommendation
31	BPP-3	Selection	1980	4.8	1.34	28.1	11.0	W 400	--
32	BPP-4	Selection	1980	6.0	1.15	23.0	10.5	W 400	Poor Shelling %
33	BPP-5	Selection	1980	5.2	1.25	24.0	11.0	W 400	Early bearer and poor Shelling %
34	BPP-6	Selection	1980	5.2	1.44	24.0	10.5	W 400	Long duration
35	BPP-8	Hybrid	1993	8.2	1.89	29.0	14.5	W 210	Early bearer
36	BPP-10	Hybrid		8.1	2.14	29.3	14.9	W 210	Bold nuts

37	BPP-11	Hybrid		6.8	1.87	28.0	14.7	W 240	Suitable for high density planting
Regional Research Station, Vridhachalam, TNAU, Coimbatore, Tamil Nadu									
38	VRI-1	Selection	1981	5.0	1.4	28.0	7.2	W 320	Suitable for coastal region
39	VRI-2	Selection	1985	5.1	1.45	28.3	7.4	W 320	Wide acceptability
40	VRI-3	Selection	1991	7.2	2.16	29.1	11.7	W 210	Early flowering
41	VRI-4	Selection	2000	6.6	--	28.5	--	W 240	Mid season flowering
42	VRI-5	Hybrid	2009	7.2	--	30.5	13.2	W 210	Cluster bearing
Regional Fruit Research Station, Vengurla, KKV, Dapoli, Maharashtra									
43	Vengurla -1	Selection	1974	6.2	1.39	31.0	19.0	W 240	Early flowering and medium size nuts
44	Vengurla -2	Selection	1979	4.3	1.0	32.0	24.0	W 320	Short duration, small nuts and high yield
45	Vengurla -3	Hybrid	1981	9.1	2.09	27.0	14.4	W 210	Bold nuts
46	Vengurla -4	Hybrid	1981	7.7	1.91	31.0	17.2	W 210	Cluster bearing
47	Vengurla -5	Hybrid	1984	4.5	1.0	30.0	16.9	W 400	Compact canopy
48	Vengurla -6	Hybrid	1991	8.0	1.91	28.0	13.8	W 210	More fruiting laterals
49	Vengurla -7	Hybrid	1997	10.0	2.9	30.5	18.5	W 180	Bold nuts
50	Vengurla -8	Hybrid	2001	11.6	--	---	17.5	W 180	Bold nuts
51	Vengurla-9	Hybrid	2015	8.9	2.2	29.3	15.9	W 210	Bold nuts
Cashew Research Center, ICAR-CCARI, Goa									
52	Goa -1	Selection	1999	7.6	2.2	30.0	7.0	W 210	

53	Goa -2	Selection	2007	9.4	2.3	29.2	5.5	W 210	Yellow and big apple
54	Goa Cashew -3	Selection	2017	8.2	2.26	29.5	10.0	W 210	
55	Goa Cashew -4	Selection	2017	8.2	2.68	29.6	12.0	W 210	
Regional Research Station, Jhargram, BCKV, Kalyani, West Bengal									
56	Jhargram-1	Selection	1989	5.0	1.5	30.0	8.5	W 320	
57	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									
58	Bhubaneswar -1	Selection	1989	4.6	1.47	32.0	10.5	W 320	Cluster bearing and high shelling percentage
59	Jagannath	Hybrid	2008	8.6	--	32.5	10.5	--	Mid season flowering
60	Balabhadra	Hybrid	2008	7.4	--	30.0	10.0	--	Early variety
	Cashew Research Centre, Jagadalpur, Indira Gandhi Krishi Viswa Vidyalaya (IGKVV), Raipur, Chattisgharh								
61	Indira Kaju-1	Selection		10.5	--	28.6	15.5	--	Cold tolerance

Cashew Processing: An Indian Perspective

Kalbavi Prakash Rao, Kalbavi Cashews, Mangaluru

History: Cracking the nuts

First organized Factory- Peirce Lesli India Ltd, Kulshekar, Mangalore

Evolution of seed treatment

▶ Hot Oil Bath Roasting

▶ Drum Roasting

▶ Steam Cooking

▶Steam Roasting Technique- Innovation of Mangalore

▶No alternate technology for the last 4 decades

Evolution of Cracking

▶ Stone or Mallet

▶ Venkappa's Cutter

25 years- most efficient way to crack)

▶ Buddhi Automatic Sheller

Ushered in mechanization

Vietnam Cracking line

Ushered in scale of manufacturing

Reduced manual labour by 75%

Reduced processing cost by half making Vietnam the cheapest manufacturer

Fig: Images showing evolution of cracking

The Rise of Machines

The Art of Drying and Humidification

DRYING PROCESS

- Brick Borma- Heat transfer by convection- shuffling of trays
- Metal Driers- Quick heating, Quicker drying
- Hot Air Driers- Fill it, Forget it.

HUMIDIFICATION PROCESS

- Stagnated water puddle and fan
- Foggers/humidifiers
- Humidification through Honey comb sheets

The Peeling Revolution

- Manual hand peeling
- Manual peeling-7 kgs per day
- Conversion of the Garlic peeler (Air cleaning technology)
- Garlic Peeler- 100 kgs/hour
- Vietnam copy of Italian peeling machine(improvised)
- Vietnam Peeler – 450 kgs /hour
- Manual labour reduction- 3 per bag to 0.2 per bag

Grading Technology

- Manual grading – 50 kgs per day
- Colour sorting- 350 kgs per hour- accept/reject process
- Nano Sorting- 250 kgs per hour – single pass 5 grades

Manual vs Machines

- Manual – total employees required for 1 MT processing=88
- Mechanical processing – total employees required = 8
- @Avg Rs 500/employee-
- Manual processing cost/MT: Rs 44000.00
- Mechanical plant cost /MT: Rs 4000.00
- Can Rs 40/kg difference sustain?

Vietnam Story

- 1980- started processing manually: Avg Size of Factory -3 MT/day
- Total Processing: 150,000MT
- 1995- Started Mechanical processing: Avg size of factory- 7 MT/day
- Total processing: 500,000MT
- 2000- Introduced automation: Avg Size of Factory- 20 Mt/day
- Total processing: 800,000 MT
- 2005- Learnt to Scale – Avg size of factory- 50-60 MT/day
- Total processing: 15,00,000 MT
- 2020- Totally Automated the plant- Avg Size of Factory- 100-150 MT/day
- Total processing: 30,00,000 MT (66% of the world crop)

The Indian Story

- Remained manual processing till 2005: Avg Factory size: 3-5 MT/day
- Total Processing: 7,00,000 MT
- 2005- Introduced partial mechanization- Avg Size of Factory: 5-8MT
- Total Processing: 8,00,000 MT
- 2010- Cutting section mechanized- Avg Factory Size: 10-14 MT/day
- Total Processing: 10,00,000 MT
- 2015- Initiated copying Vietnam – Avg Factory Size: 14-20 MT/day
- Total Processing -12,00,000 MT
- 2020- 30% industries completely automated- Avg Factory Size: 20 MT/day
- Total Processing – 15,00,000 MT (33% of the Global crop)

India's Export Performance

- Y2000- Exports 127,000 MT, Domestic: 60,000 MT
- Y2005- Exports 110,000 MT, Domestic: 1,00,000 MT
- Y2010- Exports 75,000 MT, Domestic: 178,000 MT
- Y2015 – Exports 60,000 MT, Domestic: 239000 MT
- 2020- Exports 55,000 MT, Domestic: 336,000 MT

India vs World

- India 1990- Largest producer, Manufacturer, Exporter
- India 2020 – Largest consumer
- Vietnam 1990- Just commenced manufacture
- Vietnam 2020 – Largest manufacturer/Exporter
- Africa-1990- Only a Producer
- Africa-2020- Largest Producer, commenced Manufacture

Looming Threats

- Africa takes up processing agenda in a big way
- USA fixing supply chain, wants Africa to be the largest manufacturer
- Vietnam- Develops Cambodia as its backyard producer

- Vietnam- has a huge potential to develop China as its internal market
- India- Crop shrinking – urbanization, unviable for farmers, unable to cope with scaling
- Indian Domestic market looks saturated- export vs Domestic prices narrow differences
- Indian market Highly protected by high duty on import of finished kernels
- Lost out completely on export front; no buyer keen to visit India

The Way Forward….

- Increase Indian Crop to 2 MLN MT ASAP
- Replace existing plantations with 200 nut count varieties
- Post harvest treatment: A must for farmers to sustain value
- Introduce Productivity Linked Incentive (PLI) to encourage scaling and beat Vietnam
- Develop cashew clusters in Amul pattern

Nutrient management in cashew

S. Mangalassery, J.D. Adiga, Babli Mog and V. Thondaiman

ICAR- Directorate of Cashew Research, Puttur 574202, Dakshina Kannada, Karnataka, India

Introduction

Cashew (*Anacardium occidentale*) is an important horticultural crop in India, contributing to foreign exchange. In India, cashew is mainly cultivated along the coastal region of India. The important cashew growing states are Maharashtra, Karnataka, Kerala, Goa along the west coast and Andhra Pradesh, Odisha, Tamil Nadu, Puduchery and West Bengal along the east coast. It is also grown in other non-traditional areas such as Bastar region of Chhattisgarh and Kolar (Plains) regions of Karnataka, Gujarat, Jharkhand and in NEH region. The total area under cashew cultivation in India during 2016-17 is 10.41 lakh ha with a production of 7.79 lakh tones and average productivity of 745.6 kg ha^{-1}. The productivity of cashew in India is only 745 kg ha^{-1} in the year 2014. Of the several factors associated with low productivity, poor soil fertility and lack of adequate care are the major factor limiting production. Being a hardy, fast growing drought tolerant tree, cashew is predominantly cultivated as a rainfed crop in soils of low fertility and highly degraded lateritic hillocks. In traditional farming, the cashew trees seldom receive nutrients and water. Continuous non application of fertilisers and manures lead to multi-nutrient deficiencies in soil. The experimental studies shows that cashew respond very well to fertiliser application.

Soil characteristics of cashew growing areas in India

The soil survey studies conducted at predominant cashew growing areas revealed depletion of soil nutrients due to non replenishment of nutrient removal by the cashew trees. Organic carbon rated as low in 2.7% samples in Puttur, Karnataka, in 20.0% samples in Vengurla, Maharashtra, 81.4% samples in Bhubaneswar and 92.9% samples in Bapatla. Available nitrogen was recorded as low in 94.3% samples in Puttur, 37.1% samples in Vengurla, 94.3% samples in Bhubaneswar and 75.7% samples in Bapatla. Cashew orchards in Pilicode, Kerala were found to be high in organic carbon and available nitrogen. The percent samples rated as low in available potassium was 65.7% in Puttur, 41.4% in Vengurla, 58.6% in Bhubaneswar, 22.9% in Bapatla and 17.1% in Pilicode. The soils were deficient in available phosphorus. The soils were also deficient in calcium and magnesium. The micronutrients such as iron and manganese were sufficient. However the soils were generally deficient in zinc (22.9 to 57.14% samples in different regions) and copper (8.57 to 32.9% samples in different regions). These results indicate growing nutrient deficiencies in soils under cashew cultivation along

west coast and east coast. Under such situation, soil test based nutrient management can not only improve the growth and productivity of cashew, but also arrest soil degradation.

Nutrient management in cashew

Like any other crops and organism, cashew too requires additional nutrient inputs for producing potential yield. Being a perennial tree crop, cashew removes considerable amount of nutrients from soil. A 30 year old cashew tree removes 2.847 kg N, 0.75 kg P_2O_5 and 1.265 kg K_2O. If the continuous removal by cashew tree is not balanced by application of manures and fertilisers, the yield and quality of produce will be affected, apart from deterioration of soil health. The response to nutrient application varies from location to location, based on initial soil nutrient status and management practices followed. Integrated use of organic manure, inorganic fertilisers and micronutrients provide sustainable yield while maintaining soil health.

6.1. Management of soil acidity

Cashew growing soils are generally acidic. Under high acidic soil conditions, nutrients such as phosphorus, calcium, magnesium, boron and molybdenum become unavailable, and nutrients such as iron, manganese and aluminium increase to toxic levels to affect plant growth. For correcting soil acidity, liming is to be undertaken with lime, dolomite or other liming materials. Testing of soil for pH will give an idea of soil acidity. However, for finding out lime requirement special test are to be carried out, which can be done in any soil testing laboratory. Liming based on soil test is to be done while establishing plantation and periodically based on soil test. Lime may be applied any time of the year, however, to increase the efficiency, lime is to be applied immediately after cessation of heavy rains since moisture is essential for lime-soil reaction. For new plantations, apply lime 2-3 months before planting. For established plantations, once in 3-5 years will be sufficient. The ground liming materials can be either incorporated into the soil or be broadcasted as per the lime requirement. The top-dressed lime gets leached into the soil with rainfall. Incorporation of liming materials gives faster results. The time of application is April – May before the onset of monsoon.

Manuring

Since the cashew growing soils are deficient in organic matter, application of 10-15 kg farmyard manure or compost per grownup tree is recommended. This has to be undertaken in August-September, during the receding periods of monsoon. This can be applied in the circular trench along with the application of fertilizer discussed below.

In the absence of FYM, green manuring can be adopted as an alternative. Green manure crops such as glyricidia, sesbania and sunhemp can be grown along boundaries and in between two rows of cashew. Application of green manure increase organic matter content in soil. It also improves soil structure and help to reduce runoff and soil erosion. Wherever available the poultry manure can be used in place of FYM by applying at the rate of 10 kg per tree per year.

Management of major nutrients

The general nutrient recommendation for various cashew growing regions is presented in Table 1. These fertiliser doses are to be adjusted based on the soil test results, age of the plant and spacing followed. The recommendation is for normal spacing. 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 contributed from the decomposing cashew biomass fall out. It again re-iterates the need for soil test based site specific nutrient management.

Table 1. Recommended dose of fertilizers to cashew in different states

State	Nutrient dose for mature cashew plantations (5^{th} year of planting) (g/tree/year)		
	N	P_2O_5	K_2O
Kerala	500 750	125 325	125 750
Karnataka	500 750	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

Time and methods of application

Fertiliser is to be applied after cessation of heavy rains and after weeding and clearing the base of individual trees. 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. Flushing and early flowering phase (September to December) is the period of increased root activity aiding enhanced absorption of nutrients from soil. Therefore effort should be made to coincide the fertiliser application with this phase. During flushing phase there is heavy internal demand for nutrients as the tree is entering re-productive phase. Hence proper fertiliser application is essential during this growth phase. Preferably the fertilizers to cashew are to be applied in two split doses; one at the onset of the monsoon and the second during the post-monsoon period, ensuring adequate soil moisture availability. If only single application is possible due to labour constraint or other reasons, then this can be done during post monsoon period when sufficient soil moisture is available. Circular trenches of 25 cm deep and 15 cm wide are opened at distance of 0.5, 0.75, 1, 1.5 m away from trunk during 1^{st}, 2^{nd}, 3^{rd} and 4^{th} year after planting and onwards respectively in laterite soils in heavy rainfall areas in west coast. In loamy soils of low rainfall east coast fertiliser can be applied in 50 cm circular strips. The trench should be closed immediately after the application of fertilizers and green leaves can be spread as mulch. During 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} year of planting $1/5^{th}$, $2/5^{th}$, $3/5^{th}$, $4/5^{th}$ and full quantity of recommended dose is to be applied.

Management of micronutrients

Among 17 essential nutrients, the nutrients that are required by plant in small quantities are called as micronutrients. These include iron, manganese, zinc, copper, boron and molybdenum. The functions of these nutrients in cashew are summarised below (Table 2).

Table 2. Micronutrients and their role in plants

Micronutrient	**Role in plant**
Iron	It plays a major role in synthesis of chlorophyll and photosynthetic activity within the plant and plays major role in nitrogen assimilation.
Manganese	Manganese play role in chlorophyll synthesis, and are important in functioning of many enzymes in plants.
Zinc	Zinc is required for protein synthesis and for the formation of growth regulating compounds in plants.
Copper	It is important in chlorophyll formation. It is also a component of different enzymes in plant.
Boron	In plants B is required for cell division and elongation. It plays a major role in flower and seed production and hence directly related to yield.
Molybdenum	Important in protein synthesis.

The widespread occurrence of micro nutrient deficiencies in cashew growing areas is to be tackled by adequate supplemental application of micro nutrient fertilisers either through soil application or foliar spray.

Micronutrient fertilisers

Commonly used micronutrient fertilisers are listed below in Table 3; however, the list is not exhaustive.

Table 3. Micronutrient fertilisers

Micronutrient	**Source**	**Content (%)**
Iron	Ferrous suphate heptahydrate	20
	Fe-EDTA	12
Manganese	Manganese sulphate	30.5
	Mn-EDTA	5-12

	Manganese chloride	17
Zinc	Zn-EDTA	12
	Zinc sulphate monohydrate	33
	Zinc suphate heptahydrate	21
Copper	Copper sulphate penthydrate	24
	Copper sulphate monohydrate	35
Boron	Borax	10.5
	Boric acid	17
	Di-sodium octaborate tetrahydrate	20
	Solubor (for foliar application)	19
Molybdenum	Ammonium molybdate	52
	Sodium molybdate	39

Rate and method of application

Foliar application

Table 4 illustrates the recommended rates of micronutrient fertilisers for cashew. A grown up cashew tree requires about 5 litre of spray solution. The foliar spray is to be carried out at start of flushing, panicle initiation and fruit setting stages.

Table 4. Rate of micronutrient for foliar application

Nutrient	Fertiliser to be used	Rate (g/litre)
Iron	Ferrous sulphate	5
Manganese	Manganese sulphate	5
Zinc	Zinc sulphate hepta hydrate	5
Boron	Boric acid	1
	Solubor	1
	Borax	1
Molybdenum	Ammonium molybdate	1
Copper	Copper sulphate penta hydrate	1

Soil application of micronutrients

The general rates for soil application of micronutrients are available. The rate is 5 kg/ha for Zn, 2 kg/ha for B, and 1 kg/ha for Cu, 2.5 kg/ha for Mn and 0.5 kg/ha for Mo. This rate is as per nutrient basis, and while applying this has to be converted on fertiliser basis, based on the micronutrient fertilise to be used by the farmer. It is better to provide the micronutrient by including canopy coverage area in calculation. At any cost excess application of micronutrients to soil should not be done as it will adversely affect other nutrients, crop growth and yield. Soil application is only required once in two years. Since the quantity of micronutrient to be given per tree is very small, it is better to mix it with sand while applying.

Precautions in micronutrient soil application in soil.

- Apply only once in 2 years.
- Zinc fertilisers should not be applied along with phosphatic fertilisers.
- Apply only if deficiency is detected in soil testing and apply just the recommended dose.

Manuring and fertilisation in high density planting systems

Under high density planting the rate of fertilisers are to be adjusted based on the number of trees per unit area. For some regions, specific fertiliser recommendations are available for high density planting. For tree density of 400 plants/ha, 75:25:25 kg N, P_2O_5 and K_2O per ha per year is recommended.

Nutrient management under organic farming in cashew

Soil fertility and nutrient supply are one of the important factors deciding yield. It is reported that only 20% of the cultivated area under cashew receives the nutrient application. Although cashew plantations are reported to produce 1.38 to 5.20 t ha^{-1} of cashew leaf litter biomass with reported

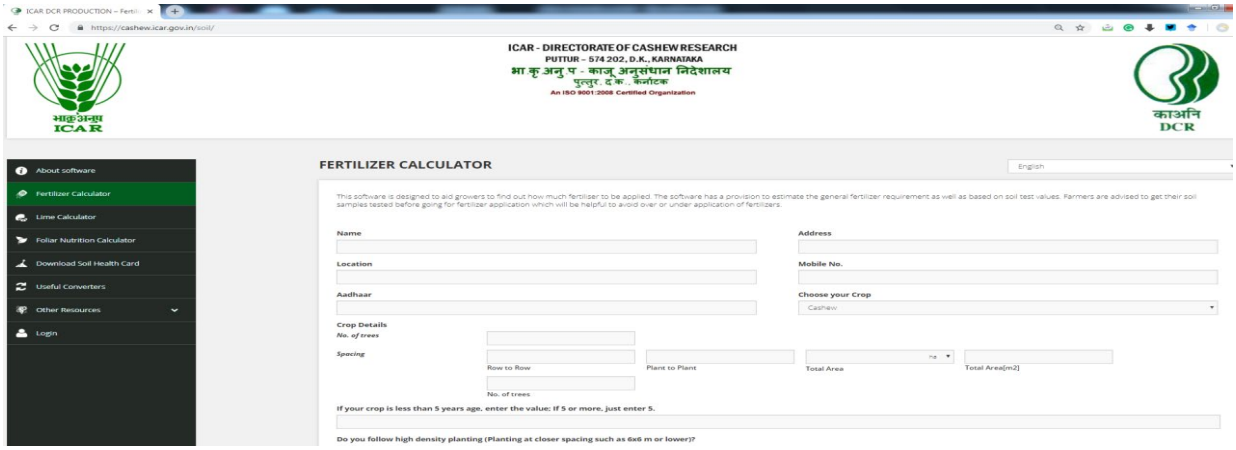
composting efficiency of 65%, these are not adequately recycled in cashew plantations. The leaf litter are removed to facilitate picking of nuts during harvest season. During other periods these may be burned or composted. However, the prepared composts are applied to other crops such as arecanut, coconut etc. These practices year after year lead to depletion of soil nutrients. Chemical fertilisers though easier way to increase growth and yield, nowadays there is more preference for organic cashew by some of the consumers. Also, there is also growing concern of increasing cost of fertilisers due to government policies and environmental concerns.

Software and Mobile App for aiding the growers in nutrient management in cashew

One of the major constraints in realizing the potential yield in cashew is the limited attention given by growers on nutrient management in cashew. The application of the right quantity of required fertilizer at the right time is vital for the judicious management of resources and for achieving the maximum benefit and income. Due to the wide variability in field conditions, and availability and choice of fertilisers, the farmers cannot correctly determine the right quantity of fertiliser to be applied and they may have to depend on scientists and extension personnel to get information on the correct doses. For empowering the farmers to take informed decision by themselves, a software and a mobile App for nutrient management in cashew was prepared under the project funded by RKVY-RAFTAAR at ICAR-Directorate of Cashew Research, Puttur.

Software on Cashew nutrient manager

This software is available in both English and Kannada. It is available on the ICAR-DCR website for calculating fertilizer requirement, lime requirement, foliar application of major and micronutrients. The deficiency symptoms of major and micronutrients commonly observed in the field also included in the software. The farmers can click on the images and understand the symptoms and find out the options to correct the deficiency. The software also lets the farmers download the soil health card issued by ICAR-DCR, Puttur. The link to the software is https://cashew.icar.gov.in/soil



The use of fertilizer calculator module

- The user needs to provide the no. of trees in the plantation. Or this will be automatically calculated if the user gives spacing followed in the plantation and total area.
- The full recommended dose is required from 5th year onwards under normal density planting and from 3rd year onwards under high-density planting. Columns are provided to enter this information in the software.
- There are options to calculate fertilizer if the user follows the high-density planting either with general fertilizer recommendation or special recommendation of fertilizer.
- If soil test reports are available, this information can be added. Based on soil nutrient status, the fertilizer rate will be adjusted automatically.
- The user can choose the rate of fertilizer recommended for his/her area in the state from the drop down menu.
- The type of fertilizer can be selected as per farmers' choice, or even a new fertilizer can be used in the calculation, providing the percentage content of nutrients, which will be available on the fertilizer bag.
- The user can generate the report with information on fertilizer rate per tree basis and the quantity required for the plantation.

The use of lime calculator module

To calculate the lime requirement, the user has to get the soil tested for Lime requirement and use the lime calculator. The user has to enter the information such as pH value (obtained after testing the soil for lime requirement), the radius of the tree canopy, the liming material available for use, and the no. of trees per unit area or spacing.

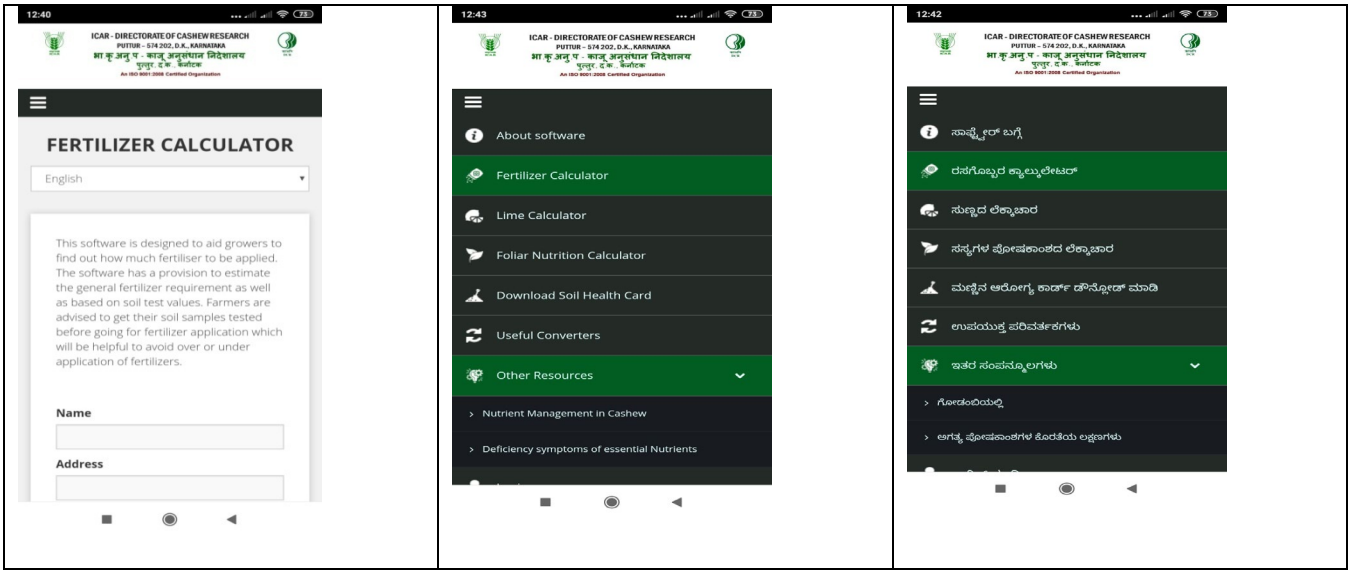
The use of foliar nutrition calculator module

For calculating, the user has to enter the following information.

- Choose the nutrient to be applied as a foliar spray
- Enter information on no. of trees or spacing & area in the plantation
- Provide the age of tree and capacity of the tank being used for spraying/mixing fertilizer.

Mobile App on cashew nutrient manager

The mobile app version of the software on the cashew nutrient manager was developed. The App has got bilingual functionality (English and Kannada). The app can be downloaded from the Google play store at https://play.google.com/store/apps/details?id=com.icarcashew.dcr_cashewnutrientmanager



Conclusions

Like any other crops, nutrient management is important in cashew also. The studies have indicated the potential to increase yield by nutrient application in cashew. Being primarily grown in lateritic acidic landscapes of low fertility, liming and nutrient application found to significantly improve the net farm income.

Literature consulted

Anonymous, 2011. Methods manual - Soil testing in India. Department of Agriculture and Coopertaion, Government of India, New Delhi, p. 217.

Anonymous, 2015. Guidelines for use of micronutrients, soil ameliorants and integrated nutrient management practices in NFSM states. National Food Security Mission, Department of Agriculture and Cooperation, Government of India, New Delhi, p. 27.

Anonymous. 2013. Indian fertiliser scenario 2013. Department of fertilisers, Ministry of Chemicals and Fertilisers, Government of India. pp. 246.

DCCD, 2018. Area and production of cashew 2017-18, Directorate of Cashewnut and Cocoa Development, Kochi.

https://www.floramax.com/nutrient-deficiencies/plant-deficiency-symptoms-flow-chart/ (Date accessed: 03-09-2018).

Mangalassery, S., 2018. Ad-hoc recommendations on nutrient deficiency management in cashew. ICAR-Directorate of Cashew Research, Puttur, India, p. 7.

Nayak, M.G., Muralidhara, B.M., Mangalassery, S., 2018. Innovative production technologies to enhance production and processing of cashew. In: Parameswaran, P.A., Jayalakshmi, V.S., Nikhil, V.M., Shine, K.K., Rohith, H.S., Lukose, V., Gopinath, L. (Eds.), National Conference on Cashew Directorate of Cashewnut and Cocoa Development, Kochi, India Hotel Swosti Premium, Bhubaneswar, Odisha, India, pp. 28-37.

Poduval, M., Yadukumar, N., 2011. Effect of different doses of fertilizers on different densities of cashew plantation. Journal of Plantation Crops 39, 35-40.

Rejani, R., Rupa, T.R., Nayak, M.G., 2013. Suitability of cashew growing areas in India - an appraisal using GIS. Journal of Agrometeorology 15, 123-128.

Rejani, R., Yadukumar, N., 2010. Soil and water conservation techniques in cashew grown along steep hill slopes. Scientia Horticulturae 126, 371-378.

Rupa, T.R., 2017. Nutrient and water management. In: Saroj, P.L. (Ed.), Cashew: improvement, production and processing. Astral International Pvt Ltd, New Delhi, pp. 233-252.

Salam, M.A., Peter, K.V., 2009. Cashew-A monograph. Studium Press (India) Pvt. Ltd., New Delhi, India. pp. 257.

Singh, D., Chhonkar, P.K., Dwivedi, B.S., 2016. Manual on soil, plant and water analysis. Westville Publishing House, New Delhi.

Yadukumar, N., Rejani, R., Nandan, S.L., 2012. Effect of organic and inorganic nutrition in cashew. Journal of Plantation Crops 40, 1-8.

Soil and water conservation, and irrigation management in cashew

S. Mangalassery, J.D. Adiga, G.L. Veena and G.N. Manjesh

ICAR- Directorate of Cashew Research, Puttur 574202, Dakshina Kannada, Karnataka, India

Introduction

Cashew is one of the important foreign exchange earning crops and is traditionally grown in the coastal region in India. The major cashew growing states in the west coast are Maharashtra, Goa, Karnataka and Kerala. Along the east coast, the major cashew growing states are Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. The non-traditional areas of cashew cultivation are Bastar region of Chhattisgarh and Kolar (Plains) regions of Karnataka, Gujarat, Jharkhand and in NEH region. In India, cashew is generally grown as a rainfed crop mainly along the coastal areas in low fertile soil. Majority of cashew orchards in India are not irrigated. The productivity levels of cashew are low in India compared to other producer countries. The research studies showed that the mean rainfall distribution in cashew area ranged from low rainfall (1500-2000 mm in Gujarat) to high rainfall (2700 to 3500 mm in West coast and NEH region). In India, the vegetative development of cashew occurs during rainy season, and the reproductive phase during the dry season. Although cashew is grown in high rainfall environment, it experiences severe moisture stress during January to May with the highest water deficit during March to May. Incidentally the critical growth phases such as flushing, flowering and nut formation in cashew also occur during these periods. Any form of stress biotic and abiotic stresses during these periods adversely affects the flowering and fruit set and results in premature nut drop and finally reduces the yield and productivity of cashew. Lack of moisture availability during fruiting season is one of the several factors associated with the low yield in cashew. Studies have shown that supplemental irrigation can significantly improve the productivity and yield of cashew. This bulletin addresses various issues in water management in cashew. The bulletin highlight the importance of water management in cashew, different options available to address the issue of irrigation, water conservation and water management for increasing the yield.

About cashew

Cashew (*Anacardium occidentale* L.), is native to Brazil and was introduced to India by Portugese travellers as a soil binding crop, to control soil erosion in coastal areas during 16th century. Sooner its commercial importance and adaptability to adverse soil and environmental conditions were recognized and its cultivation on commercial scale occurred along the east and west coast of India. Export of cashew kernels and cashewnut shell liquid bring foreign exchange to the country. In India, cashew is cultivated on a wide range of soil types such as sandy to sandy loam, laterite soil, loam and

red latosols. Due its drought hardiness, cashew is widely cultivated in degraded hillocks and slopy lands, where profitable production of other crops are not possible. Majority of cashew growing soils are low in soil fertility in terms of nitrogen, base status, cation exchange capacity and micronutrients such as zinc and boron. Due to heavy precipitation in the coastal areas where cashew is grown, the basic cations are washed out causing increased soil acidity. The high soil acidity in turn decreases the nutrient uptake by the plant, making some of the nutrients unavailable for cashew.

Water requirement of cashew

In India, the vegetative development of cashew occurs during rainy season, and the reproductive phase during the dry season. Although cashew is grown in high rainfall environment, it experiences severe moisture stress during January to May. Incidentally the critical growth phases such as flushing, flowering and nut formation in cashew also occur during these periods. Any form of stress biotic and abiotic stresses during these periods adversely affects the flowering and fruit set and results in premature nut drop and finally reduces the yield and productivity of cashew.

Water management in cashew

The cashew growing regions are characterised by high intensity rainfall over a short duration which lead to runoff and soil erosion. Cashew experience moisture stress during December/January to May which coincide with flowering and fruit setting phase of cashew, leading to flower drying and immature nut drop. Moreover the traditional areas of cashew cultivation lack access to water sources for irrigation purposes. Research studies indicate that cashew though a hardy crop respond well to water and manure management. In areas with no access to irrigation water, the water deficit to the crop can be managed to some extent by the adoption of region specific soil and water conservation practices. Adoption of such practices is part of cashew production technology in case of slopy areas to prevent surface runoff and soil erosion.

Soil and water conservation practices

Cashew plantations are raised on landscapes which are unsuitable for many other crops, and generally lack source of water for irrigation. Arranging irrigation in such landscapes will be difficult and costly. Adoption of proper soil and water conservation techniques *in-situ* in such sloppy and degraded landscapes play very important role in preventing further soil degradation by controlling soil erosion, conserving soil moisture and improving tree growth and productivity in a sustainable manner. Among different soil and water conservation techniques studied, modified crescent bunds, staggered trenches with coconut husk burial and reverse terrace are recommended for cashew orchards. The other popular soil conservation practice recommended for cashew is terrace with catch pits. These

practices were found beneficial to harvest pre-monsoon rainfall and increase the cashew yield to the tune of 32-35%. Other benefits are reduction in runoff velocity and soil loss, increased soil moisture retention and ground water recharge. With the adoption of such soil and water conservation practices, barren / sloppy lands can be brought under cashew cultivation in order to increase the farm income and land productivity.

Different technologies for in-situ soil and water conservation recommended for cashew are detailed below. The adoption of these practices should be done in accordance with the local conditions, topography, water holding capacity and infiltration characteristics of soil.

Trenches

Continuous contour trench: These trenches are taken in sloppy areas (7 to 8% slope), running through entire field length along the contour. The trench dimension recommended is 0.5 m x 0.6 m.

Modified crescent bund: The modified crescent bund consists of a crescent shaped bund of 6 m length, 1 m width and 0.5 m height at 2 m radius, which is to be taken at upstream of the cashew terrace which will help to retain water as well as litter.

Modified crescent bund for soil and water conservation in cashew orchards

Staggered trench: The staggered trenches of size 5 m length, 1 m width and 0.5 m depth are to be taken between two rows of cashew or in the middle of 4 plants, across the slope, in which coconut husks can be buried to enhance water retention.

Reverse terraces: The recommended dimensions for reverse terraces are 2 m length, 2 m width and 0.7 m depth, which are constructed so as to be inclined from periphery to the centre.

Reverse terrace for soil and water conservation in cashew orchards

Catch pits: The recommended dimensions for catch pits are 3 m length, 0.5 m width and 0.5 m depth, which are constructed upstream of cashew planted terrace, to catch and retain the runoff and to increase percolation.

Terrace with catch pits for soil and water conservation in cashew in steep slopes

Tree base terrace: Formation of tree base terrace at 2 m radius around the plant, taken over three years of planting shall be beneficial for moisture conservation. It is made by taking soil from the upper side of the slope and filling at the lower portion. The upside shall be taken in such a way that it form a catch pit to deposit soil and conserve moisture.

Bioengineering measures

Coconut husk burial: Adoption of coconut husk burial techniques with soil and water conservation techniques like modified crescent bund, staggered trenches etc. improve the water retention in soil for longer periods. This practice of coconut husk burial can be adopted around cashew plants also. Husks are to be buried in trenches of 3.5 m length, 1 m width and 0.5 m depth, opened across the slope between two rows of cashew. In such trenches 3 to 4 layers of husks can be buried with convex side

of first layer of husk touching ground. The last layer of husks should be placed with convex side upper side. Thin layer of soil and leaf materials can be placed between layers of husks. Then the trench can be filled with soil, leaving about 10 cm depth.

Coconut husk burial for soil and water conservation in cashew orchards

Use of bigger pits and mulching: This practice is to be followed during the establishment of cashew plantations. Pits of 1 m^3 size are to be dug open at recommended spacing following other soil and water conservation measures such as terracing. These pits are to be filled with topsoil, organic manure and rock phosphate at recommended rate up to $2/3^{rd}$ depth. Plant the graft at centre of this pit and proper mulching to be done.

Trenches with vegetative barriers: Inclusion of vegetative barrier along with continuous contour trenches and staggered trenches (in reversely sloppy areas) can substantially reduce runoff and soil loss. *Stylosanthes hamata, Vetiveria zizanioides* are some of the recommended vegetative barriers. Apart from helping to reduce run off and soil loss, the vegetative barriers can be harvested to provide additional income.

Green manuring and mulching: Growing green manure crops like *Glyricidia* at vacant spaces and borders provide material for mulching. Mulching the tree basin with green mulch helps to conserve the soil moisture.

Circular trench with leaf litter and coconut husk: This practice is generally recommended for east-coast areas, wherein coconut husks and leaf litter are buried in circular trenches of 0.3 m width and 0.5 m depth opened at 2 m away from the cashew trunk.

Circular trench with leaf litter and coconut husk

Supplementary/Protective irrigation

While establishing the new plantations, the planted cashew grafts requires enough soil moisture for establishment and hence it is recommended to plant the cashew grafts during the monsoon season. Under drought situation, the newly planted grafts need to be watered once in every 3 to 7 days, to ensure the root ball of the graft is kept moist, but not water logged. Once established, due to the deep tap root system, the cashew trees can survive the moderate dry season without irrigation, but with effect on yield. Cashew is known for its drought hardiness and generally grown as unirrigated, however the yield can be increased if irrigated. Wherever source of irrigation water is available, providing supplementary irrigation can benefit in improving the nut yield.

Providing irrigation @200 litres per tree at 15 days interval during November to March increases the nut retention and yield. For yielding trees, protective irrigation is to be given only after the plant enters flowering phase, during nut set and nut development stages.

By providing black polythene mulch the quantity of irrigation to be provided can be reduced to 60 L/tree once in fortnight

Drip irrigation

In drip system of irrigation water is applied through a network of pipelines and applied to the root zone of crop drop by drop by use of emitters or drippers. In this system water is applied based on ET demand of the crop and root zone is always maintained at field capacity levels.

Drip irrigation allows water saving to the tune of 40 to 70% in comparison to other methods of irrigation and 25-80% increase in yield. The water requirement in cashew is decided based on the climatic condition, canopy area and growth phase of the plant. Based on canopy coverage and daily water evaporation, the water requirement of cashew can be calculated as follows.

To meet 20% CPE

Age of tree: 5 years

Canopy spread or diameter: 4 m [mean of EW and NS length of canopy]

Ground coverage of canopy: $\pi r^2 = 3.14 \times 2 \times 2 = 12.56\ m^2$

Daily CPE = 5mm; 20% CPE = 1 mm

The 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 m^3.

1 m^3 = 1000 L

0.01256 m^3 = 12.56 L/tree/day

Advantages of drip irrigation

- It reduces direct loss of water by evaporation, seepage and percolation.
- Slow application rates facilitates easy infiltration to the soil.
- It reduces water consumption by weeds and grasses.
- It allows watering in the root zone of plant.
- Yield increases due to optimum soil moisture status at root zone.
- It can be adopted in undulating areas, where surface methods of irrigation is not possible.
- Increased water use efficiency.

Disadvantages of drip irrigation

- The drippers are clogged with soil/mineral particles and algae.
- The soil moisture is limited and depends on discharge of drippers, dripper spacing and the soil type.
- The rodents and insects may damage some of teh components of drip system.
- The initial investment and annual maintenance cost are higher compared to other irrigation methods.

Drip irrigation schedule for cashew

In cashew drip irrigation can be started from the second fortnight of December to end of March. However for new plantations, irrigation can be continued upto end of May. For well established normal density plantations, the rate of drip irrigation recommended is to meet 60% of the evaporative demand. In general, this can be met by providing 4 drippers each of 6 L/h capacity, running for 1.5 hours (that provide 36 litres of water per tree per day) during the months of December and January. The general recommendation during February and March under normal density planting is to provide 48 L/tree/day

(4 drippers of 6 L/h capacity, running for 2 hours). These rates are for grown up trees. The drippers should be installed at the base of the tree located at 1 m equidistance from the base of the tree.

In case of high density planting system drip irrigation is to be given to meet 20% of the evaporative demand. This is provided by installing two drippers each of capacity 2 L/h at the base of the tree located at 1 m equidistance from the base of the tree, running for 1 h 45 minutes (giving 7 litre water per tree per day) during December and January and running for 2 h 15 minutes (giving 9 L water per tree per day) during February and March.

Irrigation should be started only after flowering and stopped before starting the harvest. When drip system is planned right from the establishment of plantations, two drippers can be placed at 0.5 m away from the base of the tree on both sides on the lateral pipe, and another two drippers 1 m away from the base of the tree on both sides of the cashew tree. Microtubes of 1.5 to 2 m length can be connected to the drippers to facilitate changing the water dripping points near the root zone as the tree grow up over different years.

Fertigation

It is the technique of applying plant nutrients by dissolving them in irrigation water mainly through drip system. It helps to deliver the correct quantity of water and nutrients to plant roots zone. Fetigation ensures almost 90% use efficiency for the applied fertilisers, as it enables applying the nutrients at the most nutrient demanding stage of crop, at right place (at the zone of highest root activity) and right time. The right combination of water and nutrients is to be used to obtain desired results through ferigation. The advantages of fertigation are as follows.

- Higher nutrient use efficiency.
- Less pollution of water bodies through leaching of fertiliser nutrients.
- Savings of water, nutrients, energy, labour and money
- Effective application of micronutrients.
- Reduced weed growth.
- Increased yield and quality of the produce.

The disadvantages in fertigation is given below.

- Chances of non uniform distribution of fertilisers to different trees in case of any fault in the drip irrigation system.
- Cloging of emitters / laterals pipes due to precipitation of chemicals.

Fertlisers used in fertigation

The fertilisers used in fertigation should be readily soluble in water, compatible with other fertilisers, low content of insoluble matters and low corrosiveness. The general thumb rules on solubility is given below.

- All ammonium, nitrate, potassium, sodium and chloride salts are soluble.
- All sulphates are soluble except for calcium sulphate.
- All oxides, hydroxides and carbonates are insoluble.
- Urea, MOP and chelated micronutrients are generally soluble.
- Phosphates, sulphates, calcium, magnesium and trace elements may lead to precipitation and blocking if mixed or used with hard water (high in calcium and magnesium). For example, ammonium sulphate causes precipitation of calcium sulphate and magnesium as sulphate.
- Tracer elements such as Mg, Zn, B, Fe, Cu etc ., are difficult to apply through drip irrigation because they need in very low quantities, may reacts with salt in water and causes clogging.
- However chelated form such as Fe- EDDHA, Fe- DTPA can be used, on chelation the solubility increases.
- Custom made liquid Liquid fertilizer designed for fertigation are also available in the market, However this may be costly.

When fertilisers are solubilised by mixing together, they may react and tend to precipitate, if they are not compatible. Such fertilisers are better applied separately through fertigation on different days/time or different fertilisation tanks. Examples of such incompatible fertilisers are Ammonium sulphate and potassium chloride; calcium nitrate with phosphates or sulphates or DAP, MAP; Phosphoric acid with iron, zinc, copper and manganese etc.

Fertigation recommendation in cashew

It has been reported that fertigation can save 50% in the fertilizer requirement and doubled the cashew yield. Under fertigation only 50% of the recommended dose of fertiliser be given through drip and remaining may be applied in the form of castor cake (4 kg/tree/year in case of normal density planting system Or 2 kg castor cake per tree per year in case of high density planting system). The application of organic manure or castor cake may be done during August in pits dug out near water dripping point located 1 m distant from the base of the trees. The recommended dose of fertiliser need to be given in equal splits at weekly interval starting from the month of October to February. The required quantity of fertilisers are to be dissolved in water and applied through drip system.

Immediately after cessation of monsoon rains, the flushing phase get intensified in cashew and fertiliser application is highly essential during this phase. However, since flowering induction in cashew needs dry period, irrigation is not recommended during these periods. So to meet the nutrient demand 25% of the recommended dose needs to be applied as basal dose as soil application. Rest of the dose may be applied in equal split doses at weekly intervals starting from the month of October upto February. For young and establishing plantations irrigation is to be given at 100% CPE.

However under the actual field conditions, the no. of drippers, flow rate, availability of labour to run the system daily, age of the cashew trees, its development stages etc vary widely and user need to customise his/her requirement. Similarly in designing fertigation schedule the field conditions vary widely under each farmer's field and a general recommendation may not be useful. The availability of fertiliser, soil conditions, density of planting, age of the tree etc needs to be taken into consideration while formulating a fertigation schedule. To empower the users to do drip/fertigation calculations and scheduling at their convenience by inputting their specific needs and resources, a software and mobile App is being developed by ICAR-Directorate of Cashew Research, Puttur and will be shortly available on ICAR-DCR website and Google Play store.

Maintenance of drip system

Daily maintenance

- Start the pump and allow developing stable pressure.
- Clean all the filters as per the protocol.
- Open the bye pass valve meant for sending water to the drip system to obtain desired pressure in the system.
- Traverse the field and check for leakage or damage to any components. Rectify the defects by replacing the parts, removing the folds and kinks in the laterals. Check the position of drippers and microtubes and keep them in correct location if misplaced.
- Check the drippers for uniform discharge of water. Open and clean the filters if required. Do not pull the emitter from laterals as it will lead to enlargement of hole and leakage.
- Remove the end stops and flush the laterals for about 1-2 minutes.
- Flush each submain at the end of irrigation to remove the debris. This is important, since dirt are accumulated in mains and submains and if not flushed off, this may directly go the dripper and clog the pores.

Fortnightly maintenance

Clean the filters

Sand filter: Clean the sand filter by backwash, after adjusting the flow using bypass valve such that sand doesnot come out. Carefully stir the sand thoroughly while backwashing and also break the lumps if any. Continue this until clean water flows out. If the sand is not filled upto the mark indicated, refilling with new sand may be required. Since the sand filter uses special crushed silica, ordinary sand will not serve the purpose.

Screen filter: Remove the filter from the assembly, remove the rubber seals from both ends and clean with a light brush in running water.

Disc filter: Remove the filter from the assembly, remove the rubber seals and clean in running water.

Monthly maintenance

If required perform acid treatment to remove precipitated salts from drippers, microtubes and laterals.

Perform chlorine treatment to remova algal growth, slime and bacterial growth.

1. Clogging of emitters is one of the major problem in drip irrigation systems. Take out the emitter/micro tube from lateral pipe and shake it or blow it to remove the trapped dirt. Openable types of emitters can be opened and clean with accessories such as needle.

2. Leakage in the lateral, main and sub-mains: Cut the damaged part and connect it with joiner/connector.

3. Flush and clean the filters by opening and cleaning the screen

4. Flush the sub-mains and laterals by releasing the end caps.

5.Lubricate the movable screws and parts of the system both after using and when not using.

Care during rainy season

Before the onset of rainy season, back wash by flushing the system after removing the end cap of the lateral pipes. Replace the end cap of lateral pipes, roll the lateral pipes in circle and place near sub main pipe at a high elevation.

Literature consulted

Anonymous, 2011. Methods manual - Soil testing in India. Department of Agriculture and Coopertaion, Government of India, New Delhi, p. 217.

Anonymous, 2015. Guidelines for use of micronutrients, soil ameliorants and integrated nutrient management practices in NFSM states. National Food Security Mission, Department of Agriculture and Cooperation, Government of India, New Delhi, p. 27.

Anonymous. 2013. Indian fertiliser scenario 2013. Department of fertilisers, Ministry of Chemicals and Fertilisers, Government of India. pp. 246.

DCCD, 2018. Area and production of cashew 2017-18, Directorate of Cashewnut and Cocoa Development, Kochi.

https://www.floramax.com/nutrient-deficiencies/plant-deficiency-symptoms-flow-chart/ (Date accessed: 03-09-2018).

Mangalassery, S., 2018. Ad-hoc recommendations on nutrient deficiency management in cashew. ICAR-Directorate of Cashew Research, Puttur, India, p. 7.

Nayak, M.G., Muralidhara, B.M., Mangalassery, S., 2018. Innovative production technologies to enhance production and processing of cashew. In: Parameswaran, P.A., Jayalakshmi, V.S., Nikhil, V.M., Shine, K.K., Rohith, H.S., Lukose, V., Gopinath, L. (Eds.), National Conference on Cashew Directorate of Cashewnut and Cocoa Development, Kochi, India Hotel Swosti Premium, Bhubaneswar, Odisha, India, pp. 28-37.

Poduval, M., Yadukumar, N., 2011. Effect of different doses of fertilizers on different densities of cashew plantation. Journal of Plantation Crops 39, 35-40.

Rejani, R., Rupa, T.R., Nayak, M.G., 2013. Suitability of cashew growing areas in India - an appraisal using GIS. Journal of Agrometeorology 15, 123-128.

Rejani, R., Yadukumar, N., 2010. Soil and water conservation techniques in cashew grown along steep hill slopes. Scientia Horticulturae 126, 371-378.

Rupa, T.R., 2017. Nutrient and water management. In: Saroj, P.L. (Ed.), Cashew: improvement, production and processing. Astral International Pvt Ltd, New Delhi, pp. 233-252.

Salam, M.A., Peter, K.V., 2009. Cashew-A monograph. Studium Press (India) Pvt. Ltd., New Delhi, India. pp. 257.

Singh, D., Chhonkar, P.K., Dwivedi, B.S., 2016. Manual on soil, plant and water analysis. Westville Publishing House, New Delhi.

Yadukumar, N., Rejani, R., Nandan, S.L., 2012. Effect of organic and inorganic nutrition in cashew. Journal of Plantation Crops 40, 1-8.

Goyal, M.R., 2012. Management of drip/trickle or micro irrigation. Apple Academic Press, New Jersey, USa. pp. 408.

http://jainpipe.com/Designtechnical/maintenance%20guidelines%20for%20filters.htm

Establishment and management of cashew orchards and intercropping in cashew

J. Dinakara Adiga

Principal Scientist (Horticulture)

ICAR- Directorate of Cashew Research, Darbe (P.O), Puttur, Dakshina Kannada,Karnataka

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.

1. **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.

2. 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.

3. 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.

4. 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 Agronomic Practices

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. As cashew bears flowers on current season shoots, pruning of leader or lateral shoots encourage new shoot production.

Training of young cashew plantation

In case of the new plantations with the grafts the plants should be trained in the early years i.e., 2-3 years so as to provide better plant architecture which facilitates the easy inter-cultural operations. Training indirectly assists in ease of other operations such as weeding, manuring and pest and disease management (Satpathy, 1988). The lateral shoots arising from rootstocks need to be removed periodically till 2-3 years. This will assure the proper growth of the scion portion of the grafts. The grafted plants should be shaped by removing the branches and water-shoots growing from the main stem up to a height of 0.75m to 1.0m from the collar region during first 3-4 years. Besides, weak and interloping branches

should also need to be removed. After the age of 4-5 years, in tall type of cashew plants the main trunk may be de-topped at a height of 4-5 m from the ground region. This will ensure a round globular canopy which helps to harvest maximum sun light for photosynthesis. Severe pruning of the young grafts may be avoided at it may extend the juvenility and the pre-bearing period of the plants (Nayak et al., 1996).

In general, two types of training systems are being practiced in cashew, a) Modified leader system and, b) Open centre system.

a) Modified leader system:

In this system, cashew grafts are allowed to grow as single stem up to a height of 75 to 100 cm by removing side sprouts. Then lateral branches are allowed to grow at desirable direction by de-topping. De-topping height varies from 2.5 to 4 m depending on spacing. Under normal spacing (8m x 8m), de-topping at 4 m from ground level is recommended. Whereas, for high density planting (5m x 5m), de-topping at 2.5 m from ground level is recommended. Removal of cris-cross branches and trimming of branches has to be resorted to get dome shape canopy and the same should be maintained in later years by imposing mild pruning. This kind of canopy helps in reducing week shoots and water shoots development. Modified training system is suitable for both normal and high-density planting system.

b) Open centre system

Cashew grafts are allowed to grow straight upto 50-60 cm from ground level. The terminal growing point is pinched off to form lateral branches. The branches are regulated to grow in four directions at equal distance. Because of fast vegetative growth, the canopy spreads rapidly. To avoid this, canopy centre needs to be opened once in a while to support more light interception to the interior plant parts. This encourages flowering at inner and outer surface of canopy and thus increases the yield (Nayak et al., 2019).

Pruning in the established plantations

The trees which are not received any training and pruning in the initial years grow haphazardly and resulting in canopies without desirable shape and size. Besides, the development of deadwood, inter-mingling of branches with neighboring trees, crisscross branches, development of water shoots etc. will bring down the productivity of the tree (Nayak et al., 1996).

Deadwood/dry branches:

The dead wood/dry branches develop mainly because of the effect of shade on lower branches caused by overlapping of the upper branches. Deadwood will be an additional burden to the plants. Furthermore, the dead and decaying woods may invite the entry of pathogenic organisms or saprophytic growth which may spread to heal their parts of the plant in due course of time.

Crisscross branches:

The lower branches remain crawling on the ground for want of space and sunlight, where the plants are not trained or pruned in the initial years. Similarly, the branches at higher level also grow haphazardly in search of sunlight resulting in irregular canopy architecture.

Intermingling of branches:

The problem of entangling of branches starts after 10-12 years in regularly spaces (8x8 m) plantations. The exterior branches get entangled with neighboring trees as a result only a portion of canopy (crown portion) remains exposed to sunlight. Such a development inside the plantation is a hindrance to the regular intercultural operations and general maintenance of the orchard.

Water shoots/sprouts:

Water shoots are vegetative shoots which are extraordinarily vigorous growing from dormant buds at higher points on main stem in upright direction. They grow at the expense of parent branches from which they arise. They are erect in growth and much thicker in size than the normal branches and bear much longer and coarser leaves. These branches outgrow the rest of the neighboring drooping branches. If water shoots are not removed in time, they soon cover the centre of the canopy and obstruct sunlight.

The old trees with deadwood, crisscross branches, water shoots and inter mingling branches should be pruned at least once in 2-3 years. Pruning can be taken up in dormant season i.e. at least 2-3 months earlier to productive flushing. All the types of unwanted growth mentioned before are to be pruned off. However, the plant should have a better look and structure after pruning. This can be achieved using one's discretion and experience in pruning and orchard management.

Leader shoot pruning

Cashew trees enter a brief resting period after the harvest of the crop (May - June) and it continues up to next productive flushing season (September - November). The flushes or flower bearing twigs are known as lateral shoots. These shoots usually form the terminal portion of a leader shoot will give a single shoot (lateral) from its terminal bud. If the terminal bud is disturbed by means of pruning the dormant lateral buds will sprout resulting in more number of lateral shoots per unit area. This will result in increased number of productive inflorescences.

Pruning the leader shoots can be taken up at least 2-3 months (July to August) before flushing. In a tree about 50-60% of the leader shoots may be headed back to one-third of their original length. A pair of leaves may be retained while pruning wherever possible. While pruning, the leader shoot should be of a pencil thickness and should not have turned to ash color before taking up pruning.

Precautions to be taken while pruning

As a natural response the cuts resulting from pruning will heal faster if cuts are smooth and non-jagged. While attending pruning the following points are to be considered

a) While removing the deadwood the cut must be made back to living tissue as good callus formation and healing cut end is only possible form properly made cut end only.

b) It is essential to make the cut close to the branch. The cut should be nearly even along the stem or trunk leaving a minimum stub and clear wound for faster healing.

c) In the case of pruning off the diseased part care should be taken to remove all the infested parts.

d) Wherever larger branches are being removed, care should be taken to avoid breaking way of bark or wood portion of the plant.

e) When a cut is made a considerable amount of hardwood will be exposed and it should be protected from pests and pathogens. All the larger cuts may be treated with 10% Boredeaux paste while the leader shoot pruned canopy may be sprayed with 1% Boredeaux mixture.

f) It is essential to relate the appearance of the plant while pruning. Plant should have a balanced and natural appearance after pruning.

Mechanization of pruning

Selecting the best and using the right tools to prune trees and shrubs makes the pruning job quicker, easier, and safer, resulting in less plant damage. Before starting the pruning task, set the target and select the right tool for the job. It is important to use the tools as intended during the pruning work; and to maintain and store the tools appropriately after the task has been completed. There are many types and sizes of tools available for pruning. Manufacturer's produces specialized pruning tools such as left-handed models, small-hand pruners and tools with ergonomic handles. One who regularly uses pruner should purchase tools that fit their hands and are easy to use.

Using the right pruning tool for the job and using it correctly is safer for the operator and produces cleaner cuts on the plant. It is crucial not to twist or strain the blades when using cutting tools. Do not cut with the tip of the blade, but set the branch to be cut as deep as possible in the jaws of the prunes to make a clean cut. Twisting, dragging, or rotating the tool while cutting can often result in low quality cuts. Use sharp scissors or a pruning knife to trim any tears or rough edges that result from a poor cut.

C) Intercropping And Mixed Cropping In Cashew

Introduction

Cashew is cultivated both in west coast and east coast regions of India. In west coast, lands are level at the seashore and undulated in the interior areas. The climate is warm and humid with temperature ranging

from 22 to 38°C, relative humidity 75 to 85% and mean annual rainfall above 3500 mm. The soils are mainly laterite or gravelly and porous with mostly acidic particularly in hilly tracts. Because of undulating topography soil erosion is a major problem in exposed areas. In east coast land is level and soils are sandy, red sandy loam, red loamy and laterite. This area receives rainfall ranging from 600 to 1500 mm annually. Climate is warm and subhumid or dry with temperature ranging from 25 to 40° or 42°C and relatively humidity from 40 to 60%. In arecanut and coconut plantations, intercropping and mixed cropping in the interspace to reduce soil erosion and to augment additional income have been well documented. Selection of intercrops in high density planting system is made with short and long term perspectives, annuals for immediate returns and perennials and fuel trees for sustained income on a long term basis. In India cashew is mainly grown by small holders in marginal lands despite the fact that it fetches valuable foreign exchange. Only in recent years, its economic importance has been realized and attempts were made to increase its productivity through improved management and better varieties. Intercropping was not viable earlier as cashew itself was grown on soils with low water availability and fertility. With establishment of large plantations and adoption of systematic package of practices, intercropping is practiced to obtain returns during the initial years of cultivation. Once cashew canopy becomes dense intercropping (legumes and millets) is discontinued. Mixed cropping with other tree species is not widely practiced though there are some reports of casuarina being planted along with cashew in Andhra Pradesh and Orissa. Some of the common intercrops that can be grown in cashew plantations in west coast and east coast of India are discussed in this paper with special emphasis on labour and material inputs, returns and profit.

Options of intercrops in cashew orchards

Pineapple as intercrop

Pineapple can be grown as intercrop in cashew garden profitably for the first 7 years. Both main and intercrop can be planted simultaneously . Normally pineapple can be grown as intercrop in the interspace available between two rows of cashew plants. Here spacing 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). 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 fertiliser is 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. Replanting should not be done in the old trenches. Covering the fruits in the peak summer season with dry grass or weeds and tying the crown leaves around the fruits will protect from sun scorch and crown damages. Damage by rodents can be eliminated to some extent by keeping rat poisons in feed materials. Timely harvesting as and when fruits have shown signs of ripening (yellow tinge at the bottom of fruits) is the best way to avoid damages due to sunscorch and crows. The suckers having 8-10 leaves originated at base below the fruit should be removed and planted afresh. Normally in the fourth year, replanting is done and the same can be maintained for another 3 years. Beyond 7 years it is not advisable to take up pine apple cultivation as intercrop in cashew garden as by then, the shade cast over the pineapple is too much, resulting low recovery of yield which is not economical . Added to this it will be very difficult to pick cashew nuts falling in pineapple trenches as cashew attains peak yielding stage during that period. Advantages of growing pineapple in trenches dugout across the slope between two rows of cashew are that there will be better soil and water conservation which will have indirect benefit over main crop (cashew). Studies conducted at NRCC, Puttur showed that by growing pineapple as intercrops across the slope between two rows of cashew in west coast region has indirect beneficial effect on main crop (cashew) resulting in 1.5 times increase in yield as compared to plot where cashew alone is grown. This was mainly due to increased soil moisture conservation and due to control of weed as interspace is used for pineapple cultivation.

Pepper as inter / mixed crop

Pepper can be grown as intercrop trailing on the stem and branches of grown up cashew trees (more than 6 years). 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. One split dose (⅓rd of full dose) may be applied in May soon after the receipt of pre-monsoon showers and other split dose (⅔rd of full dose) during August when moisture in soil still remains towards the end of rainy season. Pepper as intercrop trained on to stem of grown up cashew tree can be grown in west coast region without irrigation. But with irrigation, both main and intercrop will be benefited. In east coast region, growing pepper under unirrigated condition may not be feasible due to low rainfall ranging from 600 to 1500 mm annually. However, this can be grown under irrigated condition in east coast regions also using cashew plant as standard for pepper vine. High price for pepper makes farmers in west coast region, particularly Kerala and coastal districts of Karnataka to go for pepper cultivation on any live or dead standards. Growing pepper on coconut and arecanut palms is a common practice in this regions. Even on cashew, pepper can be grown and good profit can be obtained. Nearly 5 to 6 years after planting with fairly good management a farmer can get up to 1.5 kg dry pepper per vine trained on to stem of cashew tree. Pepper vine can remain normally for 18 years and it can fit in very well as an intercrop in cashew gardens.

Ginger as intercrop

Ginger can be grown as an intercrop in the initial 3 to 4 years of cashew plantation in west coast region. 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

tonnes/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 is prone for deadly disease Rhizome rot. Once this disease appears, controlling is very difficult in west coast region.

Fodder and legume forages as intercrops

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 the legume fodder crops. *Sonthus hamata* ranked first in green fodder yield (12.55 t/ha) followed by *Mimosa invisa* (10.25 t/ha) and *Lupinus lupins* (7.28 t/ha).

Vegetables as intercrops

In west cost region, growing bitter gourd as an intercrop during the Kharif season has been found most profitable. Total yield expected from bitter guard is 100 kg/ha as intercrop. In east coast region possibility of growing different vegetables and oil seed crops as intercrops is more, as the interspace between rows of cashew can be easily ploughed by farm machines or bullock drawn inter cultivation implements due to the availability of level lands and, it is easy to take up such intercrops during Kharif season. It was observed that in Orissa and West Bengal growing cowpea as an intercrop has been found most profitable Whereas, at Vridhachalam growing groundnuts was found most profitable as intercrop.

Nursery Management in Cashew

N. Yadulumar

Principal Scientist (Rtd.), ICAR- Directorate of Cashew Research, Darbe (P.O), Puttur, Dakshina Kannada,Karnataka, India

Cashew was introduced from Brazil during 16th Century for soil conservation purpose. During 1950s-1980s Directorate of Soil Conservation,Orissa, planted cashew using seedlings as planting material for soil conservation purpose but not with the intention of commercial viability. After 1970, it gained commercial importance – as a horticultural crop. Then ICAR Funded Schemes /MSCP/AICRP on Cashew Centres / NRCC.

Productivity of cashew

Productivity of cashew in India is 706 kg/ha whereas in in Vietnam it is 3040 kg/ha. Low productivity in India is due to presence of 30 % of area under cultivation (mostly senile plantation) is seedling origin of unknown varieties. This has to be replaced with grafts of known high yielding varieties.

Grafts produced in India and potential areas identified for planting

Nearly 75 to 80 lakh grafts are produced in India every year. These are used to replace senile plantations and fresh planting in potential traditional and nontraditional areas. Nearly 25000 ha area is freshly planted with grafts every year. Being a cross pollinated crop, cashew cannot produce true-to-type progenies through seed. Vegetative propagation can preserve genetic identity. Though cashew can be propagated by several vegetative means, “soft wood grafting(wedge-cleft) is most successful one. Advantage is propagation all-round the year.

Terminologies

Grafting: - Joining of two plant parts.

Root stock: - Lower portion of the graft which has the root system.

Scion: - A short piece of detached shoot (lateral shoot) which when united with root stock results in the upper portion / canopy of the grafted plant.

Wood / Sap wood (xylem): - Through wood sap is drawn up from the roots and translocated to leaves.

Bark (Phloem): - The carbohydrates synthesized in the leaves will be distributed to roots via phloem. Protecting the phloem, there is an outer skin called the bark.

Cambium layer:-One celled thick strip around the outer side of sap wood (xylem) and inner side of bark (phloem). Manufactures new growth. Rapid multiplication of cells. Important in healing of graft joint / establishing the connection between root stock and scion.

Infrastructure required for nursery

- Nursery area with fence.
- Store room, grafting sheds/poly houses.
- Water source (open well/bore well), overhead tank, Irrigation system with water points.
- Pandal / polyhouses.
- Power tiller/tractor, wheel barrows, sprayers, irrigation hose pipes.
- Spades, sickles, pruning secateurs, grafting knives, nursery stools, whet stones/sharpening stones, plastic buckets etc.
- Cashew scion bank.

Establishing scion bank

- Select suitable variety.
- Grafted plants from high yielding mother plants to be planted at 4m x 4m spacing.
- Fertilize the plants @ 500:125:125 g NPK during mid monsoon
- 20-25 kg FYM/plant.
- Protect young sprouts from TMB attack by spraying 0.003% lambda cyhalothrin
- Remove the panicles for obtaining maximum scion sticks
- Pruning the plants in Sep-Oct at 1.5m height from ground level can restrict the height and increase number of sprouts.
- Scion sticks will be available in Jan-Feb
- Farmers can establish their own scion bank by planting 8-10 plants in their garden

Fig: Scion bank

Selection and Preparation of Scion Sticks

- Select 3-5-month old scion sticks from lateral shoots.
- Selected shoot should be straight, 10-12 cm long, brown coloured and should have a dormant bud at tip with thickness equal to that of a pencil.
- The top 4-5 leaves should be dark green in colour.
- Pre-Curing of scion sticks- removal of leaf lamina retaining only the stalk.
- Scion sticks will be ideal for collection 10 days after pre curing.
- Pre-curing increases the success of grafting
- Scion stick should be collected before the sprouting of buds.
- Select the shoots which are exposed to sun.

Fig: Scion ready for separation(collection)

Collection of scion stick

- Scion sticks should be collected in cool hours of morning
- Immediately after separation dip the scion sticks in water
- Scion sticks wrapped in moist cloth can be stored for 3-4 days in 100 guage poly bags.

Fig: An ideal shoot for scion collection and scions

Raising rootstocks

Selection of nuts:

- Medium sized (6-7g) freshly collected nuts (February- April), sun dried for 3 days before sowing.
- Nuts which sink in water should be selected for sowing.

Potting mix and filling of bags

- Potting mix should contain equal proportion of sand, soil and FYM.
- Mix 10g of Rock phosphate for every 2 kg of potting mix.
- Poly bag specification- 300guage thickness; size-25cm x 15 cm
- 30-40 holes per bag – for better drainage
- Fill the media tightly in to the bags.
- Improper filling will reduce the growth of seedlings
- Leads to stunted growth
- A bed containing 1000 bags can be prepared (@ 10 bags/row x 10 rows)

Sowing seed nuts

- Soaking of nuts overnight in water enhances germination
- Soaked nuts are sown at 1-inch depth
- Irrigate the bags after sowing.
- Mulching the poly bags will hasten the germination process.
- Remove the mulch after germination

- Protect the plants with 50% shade during summer
- Regular watering of seedlings every day is most essential
- No need to water when it is raining.
- Nuts start germinating in 15-20 days
- Fresh nuts sown in summer germinate early.
- Protect the germinating seedlings from rodents and birds as the cotyledons are tasty.

Fig: Preparation media filled with poly bags, sowing of seed nuts, mulching and watering

Management of rootstock

- Prevent water logging in bags during rainy season by pressing the sides of the bag
- Spray I % bordeaux mixer or 0.1% carbendazim at 10 days interval to control collar rot in seedlings
- Sowing in rainy season invites root rot problem.
- Protect from rain in case rainy season sowing is taken up.
- Control the insects by spraying suitable insecticides.
- Ensure that the root stock grows straight by removing side shoots
- About 45-60 day old seedlings of 25-30 cm height will be ready for grafting

Fig: Root stocks ready for grafting

Soft wood grafting technique

Preparation of root stock

- Select a shady place for grafting (grafting shed)
- Leaving a pair of cotyledenory leaves, remove all the leaves in root stock seedling.
- At a height of 15-20 cm from the base chop off the top portion of seedlings
- Make a downward slit of 6-7 cm in the rootstock seedling.

Preparation of scion stick and grafting

- Select a scion stick matching the root stock and trim its length to about 10 cm

- Make a wedge shaped cut of 6-7 cm length in the basal portion of scion stick and insert it in to the cleft (vertical slit) made in the rootstock seedling
- Cambial layers of both root stock and scion should be aligned, at least on one side.
- Tightly secure the graft joint with 100 guage poly strip of 2cm
- width and 30 cm length.
- Prevent desiccation of graft joint by covering it with a poly tube of 200 guage thickness, 20 cm length and 4 cm width.
- This will hasten the process of sprouting.
- Grafted plants to be kept in shade for 2-3 weeks for better sprouting of buds.
- Shift the grafted plants to sunny place after 2-3 weeks and
- remove the poly tubes .
- Successful grafts will show the symptom of growth in 3-4 weeks' time.
- 70-80% grafts will sprout in 3-4 weeks.
- Success of grafting depends on selection of scion stick, skill of grafter, season of grafting, grafting technique and environmental condition
- Usually 60-70% of final success can be obtained.

Factors influencing graft success

- Inherent compatibility of plants.
- Vigorously growing root stock – good success.
- Skillful grafting technique.
- Environmentalfactors that promote callus formation (Opt. tem.p. 26.5^0 C – 29.5^0 C).
- Preventing scion from drying out: At the time of transportation, At the time of grafting, After grafting.
- Preventing the desiccation of the delicate callus tissue/graft joint: Tying the graft joint with a polythene strip, inserting a long and narrow polythene cap helps conserve moisture and prevents desiccation during period of healing at warm temperatures.

Stages in the formation of a graft union

Callusing stage

- From 10-30 days after grafting.
- Callus tissue is formed.
- Initially starts from the root stock, but later proliferates from both components.

Cambial bridge stage

- From 30-60 days after grafting.
- Cambial continuity between root stock and scion is established.

Healed union stage

- From 60-120 days after grafting.
- Vascular tissues are differentiated and complete union between root stock and scion takes place.

Management of grafts in nursery

- Grafted plants can be arranged on a black poly sheet to prevent striking of roots to the ground
- Shifting of plants (grading) will improve the growth of grafts
- Protect the plants in summer by 50% shade.
- Water the plants regularly except during rains.
- Remove shade during rainy season and provide proper drainage to the bags.
- Control the collar rot by fungicides.
- Spray insecticides for controlling insects.
- Remove sprouts in root stocks and remove flower panicles
- Remove polythene strip from graft joint 4-5 months after grafting.
- Remove the cotyledonary leaves about 3 months after grafting.
- Cotyledonary leaves are removed when coppery colour of leaves in scion portion turns green.
- Grafts of 5 months and above are ready for planting.
- Ideal graft should have 30 cm height, 4-5 fully grown leaves and the graft joint should be 15-20 cm above the ground.

Fig: Grafted plants in nursery provided with shade.

Fig: Grafts attacked with leaf miner, sprouts below graft union, with panicle and bent graft due to girdling.

Graft production under polyhouse

- Monsoon season is the best season for softwood grafting.
- Grafting can be done almost throughout the year with a mean success of 60-70 per cent.
- Polyhouses with misting units may be used.
- Raising of root stocks, grafting, maintenance of grafts etc. can be done inside the polyhouses.
- Gives protection from rains during heavy rainy days.
- During summer shade nets may be used.

Grafts standards for sale

- > 5 month old grafts should be used for planting.
- Healthy and erect growing.
- >25 cm tall.
- >5 mature leaves.
- Graft joint at a height of 15-20 cm.
- Graft joint should be perfect.
- Polythene strip from graft joint removed / no girdling.
- Root stock portion should be free from side shoots.
- Polythene bags should be intact / not torn.

Grafts Production Schedule

Number of polythene bags to be filled	85,500
Number of seeds to be sown (including resowing)	85,500
Number of seedlings to be grafted	72,000
Expected number of saleable grafts / target	50,000

Material required

Sl. No.	Item	Quantity	Approx Cost (Rs)
1.	Graded cashew seeds (VRI-3,Ullal1,Ullal-3,Bhaskara)	570 Kg	85500
2.	LD Polythene bags		
	25 cm x 15 cm, 300 gauge	490 Kg	68,600
	30 cm x 30 cm, 100 gauge	25 Kg	4,375
	20 cm x 4 cm, 200 gauge	10 Kg	1750
3.	LD Polythene sheet		
	Black, 300 gauge	200 Kg	28000
	White, 300 gauge	50 Kg	7000
4.	Red soil	15 lorry loads (200cft/lorry)	9600
5.	Coarse river sand	11 lorry loads (200 cfts/lorry)	154000
6.	Cattle manure	55 tonnes	146,600
7.	Copper Sulphate	10 Kg	3750
8.	Karate (100 ml x 10 nos)	1 litre	700
9.	Rock phosphate	500 Kg	3,500
10.	Agro shade net (Green colour, 50% shade); (3 mwidth 10 m length roll)	2 no.	6000
	Total (Rs.9.8 per saleable graft)		4,94,175

Expenditure for each saleable graft

SL.No.	Item	Approx Cost (Rs.)
1	Preparation of potting mixture and filling of polythene bags with potting mixture, sowing, grafting and maintenance up to 3 months (by contractor)	12.5 per saleable graft
2	Maintenance of successful grafts in the nursery after the period of first work (By contractor) under Sl.No.1, Operations like irrigation, weeding, spraying insecticides, fungicides and nutrients and shading for 5 months	5 per saleable graft

Economics

- It costs about 15 lakh rupees to produce 50,000 grafted plants, taking 65-70% as grafting success.
- To produce 50,000 plants, 85,500 bags have to be filled with mixture; to produce 75,000 root stock seedlings about 85,000 (approx. 570kg) seed nuts have to be sown.
- Cost of preparation of single graft will be around 27 rupees
- Above this supervision, watch and ward charges, depreciation value of infrastructures developed.@ Rs.3. Total cost of production works out to be Rs. 30 per graft.

Nursery Proforma-I

Month of sowing	Name of root stock (VTH 174 / VRI-1 / Bulk)	No. of seeds sown	No. of seeds germinated	Germinationn percentage	No.of seedlings obtained	No. of seedlings utilized for grafting	Remarks

Nursery Proforma-II

Proforma for recording observations in cashew nursery – Graftsuccess percentage (Year:)

Month of grafting	Root stock variety	Scion variety	No. of grafts prepared during grafting season 2016	No. of successful grafts after 3 monthsof grafting	Initial graft success (%)	No. of saleable grafts produced during the year	No. of grafts sold during planting season of 2017	No. of grafts carried to next planting season

Management of cashew stem and root borer – a major pest of cashew

TN Raviprasad

Principal Scientist (Entomology)

ICAR- Directorate of Cashew Research, Darbe (P.O), Puttur, Dakshina Kannada,Karnataka

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 fipronil 2.0 ml .

Management of tea mosquito bug (TMB) in cashew

K. Vanitha, T.N. Raviprasad, Rajashekara, H.

ICAR- Directorate of Cashew Research, Darbe (P.O), Puttur, Dakshina Kannada,Karnataka

Introduction

Cashew is known to be damaged by more than 300 insect pests and diseases worldwide limiting its productivity. Nearly 50 % of annual crop loss results due of pests and disease problems in different cashew growing regions if suitable control measures are not taken up timely. Among the pests, tea mosquito bug and cashew stem and root borer are the primary pests, while others are regional specific and are considered important in certain occasions. Depending on the climate, location, age and management measures of the plantation, each geographic region has its own distinctive pest complex. This topic presents details on tea mosquito bug, minor pests of cashew, and pollinators of cashew.

I. Tea mosquito bug

Cashew production is drastically affected by Tea Mosquito Bug (TMB) (*Helopeltis* spp., Miridae) which is one of the major pests of cashew. In India, four TMB species viz., *Helopeltis antonii* Signoret, *Helopeltis bradyi* Waterhouse, *Helopeltis theivora* Waterhouse and *Pachypeltis maesarum* Kirkaldy occur on cashew. Among them, *H. antonii* is the dominant species. Cashewnut yield loss of 25-50 per cent has been reported in different cashew growing states, and even 100 % yield loss can occur under outbreak situations.

Pest appearance:

- Adult *H. antonii* are slender, elongate, 6-8 mm long, reddish brown in colour, black head with reddish/ brownish/ blackish thorax and black and white abdomen. The nymphs of *H. antonii* are light brownish to brown in colour.
- *H. bradyi* closely resembles *H. antonii*, but has a minute colour variation in the hind femur and abdominal region. The nymphs are brownish in colour.
- *H. theivora* has longer antennae and yellowish pronotal ring and greenish white patch in the abdomen. Nymphs are greenish to greenish yellow in colour.

A pin-like knobbed scutellar process is present dorsally in both the nymphs (except first instar) and adults. Nymphs are translucent reddish brown having long antennae. The size of nymphs of *H. antonii* and *H. bradyi* are almost similar except slight variation in colour, whereas, the nymphs of *H. theivora* are comparatively smaller and slender.

(From left : *H. antonii*, *H. bradyi*, *H. theivora* and *P. maesarum*)

Biology

The eggs are white, ovoelongate, 1.0 to 1.30 mm long having two unequal extra-chorionic processes. Eggs are embedded in plant tissue singly or in small groups usually with the operculum and extrachorionic processes exposed. Incubation periods vary depending on locality, season and host plant, but generally in the range of 6 to 11 days. *Helopeltis* spp. has five nymphal instars that vary in size, colour and development of body parts. Mean nymphal developmental period of 12.60 ± 0.50 days has been reported for *H. antonii* on cashew. The pre-oviposition and oviposition periods ranged from 3 to 5 days and 5 to 10 days, respectively. The longevity varied from 7 to 46 days and fecundity from 10 to 220 days. Three pronotal colour variants occur in the adults of the *H. antonii* and *H. bradyi*: dark red (DR), black (B) and brownish black (BB). DR variants are generally more in *H. antonii*.

Host range

Variety of plants are infested by all four species of tea mosquito bug, mostly by *H. antonii* and *H. theivora*. *H. antonii* is highly polyphagous in habit and the nymphs and adults of feed on a wide variety of crop plants (more than 100 species). Important host plants include neem (*Azadirachta indica*), cocoa (*Theobroma cacao*), guava (*Psidium guajava*), drumstick (*Moringa oleifera*), cotton (*Gossypium* spp.), Singapore cherry (*Muntingia calabura*), black pepper (*Piper nigrum)*, allspice (*Pimenta dioica*), henna (*Lawsonia inermis*), mahogany (*Swietenia mahagoni*), eucalyptus (Eucalyptus sp.), apple (*Malus domestica*), avocado (*Persea americana*), camphor (*Cinnamomum camphora*), cinchona (*Cinchona* sp.), cinnamon (*Cinnamomum zeylanicum*), grapes (*Vitis vinifera*), red gram (*Cajanus cajan*), tamarind (*Tamarindus indica*), tea (*Camellia sinensis*), pepper (*Piper nigrum*), cocoa (*Theobroma cacao*) etc. Apart from these, a few weed plants in the cashew plantations also support TMB during off season especially *Chromolaena odorata, Calycopteris floribunda* etc. But, cashew is the most preferred host for TMB during the cropping season.

Distribution of the pest

The pest is distributed in most of the cashew growing regions of our country including Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu, Andhra Pradesh, Gujarat, Chhattisgarh and Orissa. The pest is severe in West coast regions compared to East coast regions. 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. *H. bradyi* is also found in high altitude Tura region, Meghalaya, while *H. theivora* is predominant on cashew in the north east region.

Nature and symptoms of damage

The nymphs and adults feed on the leaves, new shoots, panicles, and on the developing nuts. Typical feeding damage appears as a discoloured necrotic area or lesion around the point of entry of the labial stylets into the plant tissue. The lesion can be elongate or spherical and becomes darker with age. During severe infestations, the young shoots and panicles dry up, giving the infested trees a scorched appearance. The lesions on shoots and panicles coalesce and ultimately result in shoot blight and blossom blight. Successive attacks on new growth can result in stunting or death of the tree. Damage to immature nuts causes them to shrivel, while older nuts develop a blistered or scabby appearance. Infestations during the early stages of fruit set often result in an immature fruit drop. Each insect can damage 3-4 shoots or panicles during its life cycle thereby, leading to heavy loss in nut yield.

In the salivary gland of *H. antonii*, hydrolytic enzymes (protease and lipase), oxido-reductase enzymes (catecol oxidase, catalase and peroxidase) and free amino acids were detected. These salivary enzymes were implicated for the phytotoxaemia on various host plants as well as detoxification of defensive chemicals produced by the host plants.

Seasonality of pest incidence

Helopeltis spp. exhibit a more or less continuous cycle of generations throughout the year. In India, the build-up of TMB populations on cashew in October/November is synchronized with the emergence of new foliage following the cessation of the monsoon rains. Peak abundance is reached in January/February when cashew trees are in full bloom, the insects remaining active on the plants until the onset of the monsoon rains in June. In young plantations, the pest is noticed continuously with a higher intensity during January till March. There is also evidence indicating that TMB populations fluctuate in response to more localized and less regular climatic events, tending not to do well under conditions of heavy rain, high winds, or low relative humidity.

Management measures

Proper surveillance and monitoring at regular intervals for damage symptoms during flushing, flowering and fruiting period of cashew as well as on important host plants present in the surroundings of cashew plantations are required so as to initiate the management measures. Proper surveillance is very essential as the pest has a short life cycle and can inflict serious damage within a few days. Whenever, the incidence of pest is noticed on 5-10 per cent of the flushes, management measures should be initiated.

Host plant resistance

The identification of promising cashew types having tolerance to TMB infestation would be one of the most desirable and eco-friendly non-chemical strategies to manage the pest and augment the productivity. All the released varieties and nearly all the germplasms screened at ICAR-DCR, Puttur are susceptible for TMB attack and there is no completely tolerant cashew type exists against TMB infestation. Least susceptible types to *H. antonii* contain higher phenols which cannot be implicated towards resistance, because of its potential salivary detoxification mechanism. Under low to moderate pest incidence, variety 'Bhaskara' escapes TMB damage because of its mid-season flowering nature. Some varieties like Nethra Vaaman, VRI-3 shows moderate resistance nature, as they produce flushes and flowers even after initial infestation of TMB. The existence of antibiosis mechanism is also remote in cashew.

Natural enemies of TMB

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* cuspis Rajmohana and Srikumar (Scelionidae), *Chaetostricha* sp. (Trichogrammatidae) and *Gonatocerus* sp. nr.

bialbifuniculatus Subba Rao. In the East coast, *Ufens* sp. is the only parasitoid observed on TMB eggs. Nymphal adult parasitoid of genus *Leiophron* (Hymenoptera: Braconidae) was also reported on *Helopeltis antonii*. All these species are solitary parasitoids. The highest parasitism up to 70.8 per cent by *Telenomus cuspis* in certain months was recorded. Parasitism by *T. cuspis* is negligible in the eggs of *H. antonii* laid on neem in east coast (Tamil Nadu) whereas it is a dominant species in cashew ecosystem of west coast of India. *Ufens* sp., is the dominant species in the neem ecosystem of Tamil Nadu. However, the attempts to multiply these endo-parasitoids under laboratory conditions were not successful.

Predators also appear to play an important role in the natural control of *Helopeltis* spp. The main predators include spiders, reduviids, mantids and ants but all these are general predators and could not provide efficient control of TMB under higher incidence. Similarly, *Aspergillus flavus* and *A. tamarii* are reported as entomopathogens on TMB. Specific strain of *Beauveria bassiana* is also found causing mortality of TMB in certain months. However, detailed information on the effectiveness and methodology of application needs to be further developed.

Management using botanicals

The plant products tested for their insecticidal activities against TMB showed poor response in general. Neem formulations evaluated against *H. antonii* indicated low mortality and also with low feeding deterrence. However, kernel extracts of Pongamia, Calophyllum and Pongamia oil extracts gave increased mortality of *H. antonii* than any other plant extract.

Insecticidal management

The first round of pesticide spray should be given on 5-10 per cent pest incidence of the flushes. The second round of the spray should be invariably completed within 3-4 weeks, if the TMB population persists. If panicle damage is severe (> 50%) because of delayed insecticidal application, further sprays will not result in improved yields. Chemicals that can be sprayed in rotation are lambda cyhalothrin (0.6 ml/lit), thiamethoxam (0.2 g/lit) and acetamiprid (0.5 g/lit). The third spray can be a need based on in case pest population persists even after the second spray. Same insecticide should not be used for spraying for subsequent sprays in general. Although, cashew is an insect pollinated crop, spraying of insecticides during flowering season did not find to influence the fruit set. Once foraging bees face accidental death during sprays, succeeding bee progenies including many species of wild bees would have taken over the foraging activity. But it is advisable to avoid insecticidal sprays during peak foraging period of bees i.e., 11.00 am to 1.00 pm. Spraying should be done in the early hours of the

day (7 - 11 am) or in the evenings (3 – 5 pm). Spraying should be taken up immediately when initial symptoms of TMB damage are noticed. If it rains immediately after spraying, the spraying must be repeated, and entire canopy area should be sprayed. Approximately, 6-8 litres of solution is required for a tree of 15 -20 years depending upon the canopy.

Behavioural means of management

Presence of sex pheromone activity in female TMB is confirmed in studies conducted at DCR, wherein virgin TMB and mated female tend to attract males. The research is underway to identify the chemical nature of pheromone and to investigate the possibility of synthesizing it so as to use under field conditions.

Association of TMB with disease incidence

The feeding injury by the bug is one of pre-disposing factors for the infection and expression of die-back disease. hen the dried shoot is split open, discolouration may be seen in matured 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. 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.

To conclude, improving the non-insecticidal methods like use of tolerant varieties, biocontrol agents, biotechnological approaches and synthetic sex pheromone will have better scope to manage this pest and reduce the dependency on insecticidal control of TMB.

Selected References

Bhat, P.S. Sundararaju, D. and Raviprasad, T.N 2002. Integrated Management of Insects, Pests and Diseases. *In:* Indian Cashew Industries. Ed. Singh, H.P. Balasubramanian P.P. and Venkatesh Hubballii, DCCD, Kochi. pp.111-117.

Cashew pest database. ICAR-DCR. https://cashew.icar.gov.in/pestsite/

Freire, F.C.O., Cardoso, J.E., dos Santos, A.A. and Viana, F.M.P. 2002. Diseases of cashew nut plants (*Anacardium occidentale* L.) in Brazil. *Crop Protection*, **21**: 489–494.

Pillai. G.B, O.P. Dubey and Vijaya Singh. 1976. Pests of cashew and their control in India- a review of current status. *Journal of Plantation Crops*, 4 (2): 37-50.

Rai, P.S. 1984. Hand Book of Cashew Pests. Research Co- publications, East Azadnagar. Delhi. 124 p.

Sundararaju D. 1984. Studies on cashew pests and their natural enemies in Goa. *Journal of Plantation Crops,* **12**: 38-46.

Management of minor pests of cashew and pollinators of cashew

K. Vanitha, T.N. Raviprasad and Veena, G.L.

ICAR- Directorate of Cashew Research, Darbe (P.O), Puttur, Dakshina Kannada,Karnataka

Minor pests of cashew

Among the other insect pests damaging cashew, shoot tip caterpillars, thrips, leaf miner, leaf and blossom webbers, apple and nut borers are also the important pests of cashew in certain regions. Some of these pests may be problematic in certain regions. In general, management actions taken for managing TMB could manage these pests also, but separate spraying may be required during certain periods to prevent economic loss. The details of important minor pests are detailed hereunder.

(a). Shoot tip caterpillar

During active flushing period, damage to shoot tips of cashew trees can occur due to shoot tip caterpillars. This pest is regularly reported from the east coast tracts. The pale yellowish green caterpillar (*Anarsia epotias* Meyr., F: Gelechiidae) with black head webs together the tender leaves and feed within it at the early stage. Later, they bore into 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. The egg, larval and pupal period lasts for 3-4 days, 12-16 days and 7-10 days respectively and the life cycle is completed in 25-29 days. Similarly, the tiny, yellowish to greenish-brown larvae of *Hypotima* (=*Chelaria*) *haligramma* M. (Lepidoptera: Gelechiidae) 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. These both larvae also damage inflorescences in the subsequent period.

(b). Leaf miner

The leaf miner, *Acrocercops syngramma* M. (Lepidoptera: Gracillaridae) is a common pest of cashew during post monsoon period all over the country. Young plants are more prone to attack.

Caterpillars mine and feed below the epidermal layer of the tender leaves and tender shoots causing extensive leaf blisters which later dry up causing distortion, browning and curling of the leaves. As the attacked leaf ages, holes develop due to drying out of the damaged portion. During the developmental period larvae are dull white in colour and turn pinkish before pupation. After full development, larvae fall off to the soil for pupation and silvery grey adults emerge after 7-9 days. The life cycle of this pest is 20 to 25 days. Larval parasitoids *viz*., *Chelonus* sp. (Braconidae), *Sympiesis*

sp. (Eulophidae), *Chrysocharis* sp. (Eulophidae) were reported and parasitism up to 40 % has been recorded in field conditions at Puttur, Karnataka.

(c). Leaf thrips

Thrips are minute, fragile, slender, active insects and adults have fringed wings. Foliage thrips (Thysanoptera: Thripidae) *viz*., *Selenothrips rubrocinctus* (Giard)*, Rhipiphorothrips cruentatus* Hood and *Retithrips syriacus* (Mayet) attack cashew. The adults and immature stages of thrips colonise the lower surface of leaves. The thrips destroys the cells on which it

feeds cause leaf distortion, unsightly dark coloured droplets or blotches of excrement can be

seen on the leaf surface. The infested leaves become pale brown and crinkle with roughening of the upper surface. Honeydew excreted from thrips gives rise to black sooty mould. In severe cases, shedding of leaves and stunting of growth results. If infestation occurs on cashew seedlings, whole seedling may dry up. *S. dorsalis* breeds also on many annual crops and it is observed on *Calycopteris floribunda* Lamk. (Combretaceae), throughout the year which is a quite common shrub in the cashew plantations in west coast regions.

(d) Leaf folder and leaf rollers

Several caterpillars fold and/or roll the tender cashew leaves emerging after post monsoon and feed within. Light yellowish larvae of *Caloptilia tiselaea* M. cause damage by folding the tender leaves terminally. Larvae of *Anigraea albomaculata* damage tender leaves by making spindle shaped folds. 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* F. during their early stages roll the tender leaves and scrape the green matter, later they defoliate the entire leaves.

(e). Leaf beetles

During southwest monsoon, the red coloured chrysomelid leaf beetles, *Monolepta longitarsus* Jal. (Coleoptera: Chrysomelidae) damage cashew to certain extent. These appear abundantly especially in young trees and skeletonise the leaves which gradually dry up. Tender shoots are also attacked, and shoot terminals finally dry off. When nursery seedlings are attacked the entire seedlings dry up. Tapioca, *Terminalia arjuna* (Roxb.) *paniculata* Roth (Combretaceae) are alternate hosts of this pest.

(f) Inflorescence caterpillars

A complex of webbers, loopers, bud worms, caterpillars etc occur on cashew flowers. Important species include, *Hypatima haligramma* M., *Anarsia* sp., *Lamida moncusalis* W., *Nanaguna* sp.,

Thylacoptila paurosema M., *Archips* sp., *Euproctis* sp., *Aetholix flavibasalis* G. Other caterpillars are *Dudua aprobola*, *Oenospila flavifusata, Tinolius* sp., *Perixera* sp., *Bombotelia jocosatrix* etc. Infestation by lepidopterans especially by *H. haligramma* and *Anarsia* sp. starts soon after the emergence of inflorescences and panicle/bud expansion stage. The infestation by lepidopterans gradually increases from December first week reaching a peak during the last week of December or first fortnight of January. But the population of most of the lepidopteran species decreases drastically during March. Incidence of certain leaf feeding caterpillars like *B. jocosatrix*, *O. flavifusata*, *Pingasa ruginaria*, *Perixera* sp., *Hyposidra* spp., *Euproctis* sp. and *A. flavibasalis* can also be noticed on cashew flowers between December and January especially during delayed flushing and early flowering seasons.

Damaged portions of buds, flowers, panicle rachis, drying of flowers, webbing of flower clumps and reduced nut set. Studies indicate that timely application of insecticides against lepidopteran flower pests can minimize the yield loss by 20-50 per cent depending on the nature of pest infestations and damage intensity.

(g). Apple and nut borer

Several lepidopteran, coleopteran, dipteran and hemipteran pests damage apples and nuts of cashew during different developmental stages. Among them, *Thylocoptila paurosema* M. and *Hyalospila leuconeurella* R. (Lepidoptera: Pyralidae) are important. Dark pink larvae initially damage flowers and later bore inside the tender nuts and developing apples resulting in shrivelling and premature fall. In the developed green nuts and apples, caterpillars tunnel near the junction of apple and nut and the boreholes are plugged with frass and excreta. There are 5 larval instars lasting 15- 33 days. The fully grown larvae drop to the ground for pupation and emerge as moths. The larvae of *H. leuconeurella* bore through the apple from one end to the other end and remain inside the apple till the fruit drops and when nuts are attacked, they get deformed. Recently, infestation of apples and nuts by *Citripestis* sp. has also been reported in Karnataka.

On *H. leuconeurella*, a chalcid, *Brachymeria* sp. and an Ichneumonid *Cremastus* sp. have been recorded as parasitoids. Besides, *Lamida moncusalis* Wlk., *Orthaga exvinacea* Hamps.and *Euproctis* spp. occurs as external feeders on tender fruits and apples.

(h). Leaf and blossom webber

Cashew shoots bearing fresh flushes and flowers are attacked by *Lamida* (= *Macalla*) *moncusalis* Wlk. (Lepidoptera: Pyralidae) and *Orthaga exvinaceae* Hamps. (Lepidoptera: Noctuidae). Of these, *L.*

moncusalis is a major pest in East Coast tracts. Symptoms of infestation are presence of webs on terminal portions, with clumped appearance, and drying of webbed shoot/ inflorescences. The caterpillar is dark green with yellow longitudinal bands and pinkish dorsal lines. The egg, larval, pre-pupal and adult stages last 4-7, 16-22, 9-15 and 3-6 days respectively. The life cycle is completed in 32- 47 days.

(i). Flower thrips

Flower thrips on cashew include *Rhynchothrips raoensis* G., *Haplothrips ganglbaueri* (Schmutz), *H. ceylonicus* Schmutz, (Thysanoptera: Phlaeothripidae), *Thrips hawaiensis* (Morgan), *Frankliniella schultzei* (Trybom) and *Scirtothrips dorsalis* H., (Thysanoptera: Thripidae). They attack buds, flowers, immature apples and nuts. Thrips infestation causes shedding of flowers, immature fruit drop, formation of scabby as well as, malformed apples and nuts. Up to 15-25 per cent fruit drop is noticed due to thrips damage.

(j). Mealy bug

Mealy bugs, *Ferrisia virgata*, *Planococcus lilacinus*, *Planococcus citri* and *Phenococcus solenopsis* are serious in certain cashew pockets. They are soft bodied, having milky white coating on the body. The nymphs and adults suck sap from the tender plant parts results in withering of growing shoots, inflorescence and developing fruits. It can be seen on the lower surfaces of tender leaves, twigs, inflorescence panicles and fruit peduncles. Due to honey dew secretion by mealy bugs, sooty mould develops on the affected portions. Two parasitoids *viz*., *Aenasius advena* Campere (Encyrtidae) and *Blepyrus insularis* Cameron were recorded on *F. virgata*.

Other minor pests

Apart from these pests, there are several chrysomelid beetles (importantly *Monolepta longitarsus* Jacoby, *Neculla pollinaria* Baly), lepidopteran caterpillars (*Lymantria* sp. (Lymantridae), *Metanastria hyrtaca* Cram. (Lasiocampidae), *Euproctis* spp. (Lymantridae) defoliate cashew mostly during post monsoon flushing period. In few regions, leaf folders, leaf rollers, aphids cause damage to tender cashew shoots. Besides, there are several other minor pests damaging flower buds and flowers. Most of these pests occur at very low population level, for which, management measures are generally not required.

Management of minor insect pests of cashew

- Generally, the plant protection measures 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.

- Removal of weeds in cashew plantations should be taken care, as weeds like *Chromolaena odorata, Terminalia paniculata, Getonia* sp. and are not only competitors of cashew but also serve as host plants for some 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 gradually reduces the pest population.
- Removal and destruction of mealy bug and aphid infested plant parts helps to minimize their infestation and spread. Spraying of dichlorvos 76 WSC 0.2% (@ 2.5ml / lit) or dimethoate 30 EC 0.05% (@ 1.75ml/lit) in combination with fish oil resin soap @ 20 g per litre of water reduces mealy bug incidence effectively.
- Under unsprayed conditions, an array of predators *viz*., spiders, ants, reduviids, coccinellids, neuropterans, hemipteran bugs and praying mantises take care of many of the minor pests of cashew. 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. Trees harbouring ant nests especially red ants should be spared of spraying to allow them to take care of pests naturally.
- Botanical insecticides are good biological weapons that can be best integrated with insecticides. Neem (*Azadirachta 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. While using botanicals, emulsifiers (soap water/ bar soap 0.5 % @ 5g/lit or teepol @ 0.1 %) should be used in the spray fluid.

Importance of Pollinators in Cashew

Fruit set in cashew is mainly influenced by the activity of pollinators. In cashew, inflorescences develop on current season lateral shoots. Each inflorescence has both staminate (male) and hermaphrodite flowers (bisexual) in it. Pollen grains are sticky in nature, thus wind pollination is difficult and because of position of style in the hermaphrodite flowers, self pollination is very difficult.

In general, cashew flowers are visited by diverse group of insects like ants, thrips, butterflies, flies, wasps and bees. Insect visitors documented on cashew flowers at ICAR-DCR include 40 species

belonging to 13 families of three insect orders. Many of the dipterans are just visitors of cashew flowers, and not pollinators. Similarly, wasps like sphecids and vespids
move among cashew flowers frequently which might be for nectar as well as prey insects. Similarly, several ant species move over the cashew inflorescence throughout the day period
in abundance, but the major need is for EFN at the base of flowers and buds as well as the honey dew from certain sucking pests attacking cashew inflorescences.

Based on the abundance and foraging activity, eight bee species are considered as main pollinators of cashew, *viz. Apis cerana indica, Apis florea, Braunsapis* spp*., Ceratina hieroglyphica, Tetragonula* sp*., Lasioglossum* sp*., Pseudapis oxybeloides* and *Seledonia* sp. Most species of bees visited the flowers simultaneously, and activities of *A. c. indica*, *A. florea* and *Tetragonula* sp. are noticed throughout the observation period. Peak foraging period of pollinators coincides with peak anthesis of hermaphrodite flowers and high pollen build-up in male flowers, which is very much advantageous for effective pollination in cashew. Since pollen was the foraging reward for most of the bee species, fresh male flowers were mostly preferred. Most bees collected pollen followed by nectar in the same male flower or nectar followed by pollen. Nevertheless, it is observed that the same hermaphrodite flower was visited by multiple bee species consequently, thus effecting pollination.

From left: *Pseudapis oxybeloides, Ceratina hieroglyphica, Braunsapis picitarsis*

Pollinator exclusion studies by bagging experiments indicated that bees are efficient pollinators of cashew increasing fruit set. Thus, sufficient pollinator population is required to realize good yield of cashew, as hermaphrodite flowers need to be pollinated within 4 hours of peak stigma receptivity. Encouraging bees especially the native bees by their conservation and identifying cashew genotypes with high pollinator attraction are important to enhance the productivity of cashew. Artificial bee nests

designed at ICAR-DCR, Puttur having wooden blocks with drilled holes (6 cm deep and diameter of 3.00 mm; 2.5 mm) and sticks of bamboo, lantana, Johnson's grass and cashew were very successfully occupied by *Braunsapis* spp., which are important and abundant native bee species found in the region. Thus, these trap nests can be useful tools for conservation of this bee species and pollination purpose.

Selected References

Bhat, P.S. Sundararaju, D. and Raviprasad, T.N 2002. Integrated Management of Insects, Pests and Diseases. *In:* Indian Cashew Industries. Ed. Singh, H.P. Balasubramanian P.P. and Venkatesh Hubballii, DCCD, Kochi. pp.111-117.

Cashew pest database. ICAR-DCR. https://cashew.icar.gov.in/pestsite/

Freitas BM, Paxton RJ (1998). A comparison of two pollinators: the introduced honey bee *Apis mellifera* and an indigenous bee *Centris tarsata* on cashew *Anacardium occidentale* in its native range of NE Brazil. *J Appl Ecol*., **35**(1):109–121.

Pillai. G.B, O.P. Dubey and Vijaya Singh. 1976. Pests of cashew and their control in India- a review of current status. *Journal of Plantation Crops*, 4 (2): 37-50.

Rai, P.S. 1984. Hand Book of Cashew Pests. Research Co- publications, East Azadnagar. Delhi. 124 p.

Sundararaju D (2000). Foraging behaviour of pollinators on cashew. *The Cashew*, **14**:17–20.

Sundararaju D. 1984. Studies on cashew pests and their natural enemies in Goa. *Journal of Plantation Crops,* **12**: 38-46.

Vanitha, K. and T. N. Raviprasad. 2019. Diversity, Species Richness and Foraging Behaviour of Pollinators in Cashew. *Agric Res*., **8**(2):197–206.

Cashewnut Processing

D. Balasubramanian

Principal Scientist (AS & PE)

ICAR- Directorate of Cashew Research, Darbe (P.O), Puttur, Dakshina Kannada,Karnataka

Introduction

Cashew (Anacardium occidentale L.) is a versatile tree nut and a precious gift of nature to mankind. The world production of raw cashew nut is to the tune of 37.5 lakh MT in the last fiscal year and about 32 countries contributed to this global production. Cashew nut took deep roots in the entire coastal region of India after the introduction of cashew during 16th century by the Portuguese. Beginning as a poor man's crop, it ends up as the rich man's favorite snack-food all over the world. 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. Cashew, one of the most important commercial crops in India, produced 6.13 lakh MT of raw nuts from an area of 9.23 lakh ha (DCCD, 2010). Cashew kernel exported from India reached an all time high of Rs 2,906 crores by exporting 1.08 lakh MT of kernels during the year 2009-10, accounting 60 per cent of global share.

Cashewnut processing Industries

Cashewnut processing industries have a simple organizational structure and mostly under private management i.e., either proprietorship or partnership. About 67 % of the processing units are categorized under "Labour oriented ", 18% follows mechanization partially and 15% are fully automated. Total employees' strength of these units varied from 50 to 400. Among the women force deployed, 90-95% is employed primarily is shelling, peeling, grading and packaging. Men labourers are involved in drying, stacking, roasting/ steaming, kernel drying and packing. The State Government fixes labour wages and it differs from state to state.

Structure of raw cashewnut

The raw cashew nut is the main commercial product of the cashew tree, though yields of the cashew apple are eight to ten times the weight of the raw nuts. The by-product CNSL obtained either during or after processing of the raw nuts has industrial and medicinal applications. The skin of the edible kernel is high in tannins and can be recovered and used in the tanning of hides. The Pseudo-

fruit of the cashew tree can be made into a juice with high vitamin 'C' content and fermented to give a high proof spirit.

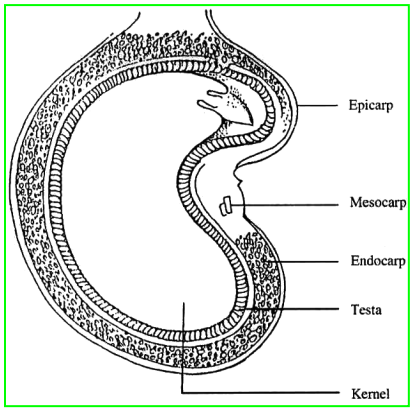


Fig 1. Cross sectional view of raw cashewnut

Raw cashewnut procurement

Cashewnut is a seasonal crop, harvesting of nuts in India starts from March to June. While procuring raw cashewnuts, normally following quality tests are conducted to assess the quality and to fix up the price.

i)	**Visual test**	Size and colour of the nuts to check the maturity
ii)	**Counts**	Number of nuts per kg and ratio of cashew kernels obtained by shelling a kilo of raw cashewnuts
iii)	**Floating test**	A random sample (2kg) is put in 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.
iv)	**Cutting test**	A random sample of 2 kg is cut open using hand cutting tool. Based on the kernel appearance i.e. white, shriveled dotted or rejects, the percentage of good kernel is calculated.

Cashewnut processing

It can be defined as the recovery of edible kernel from conditioned raw nut by manual or mechanical means. In India, the processing is mostly manual and it consists of steaming / roasting, shelling, kernel drying, peeling, grading and packing. Grading of raw cashewnuts before processing

reduces broken kernel. Conditioning of raw cashewnuts is to make the shell brittle and to loosen the kernel from the shell. Three methods are being followed in India, they are: (i) Drum roasting; (ii) Oil bath roasting and (iii) Steam boiling.

Drum roasting

In this process, the nuts are fed into an inclined rotary 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 30-45 sec and the drum is rotated manually. The shell becomes brittle and rate of shelling and the outturn of whole kernels reported to be highest among the three methods of roasting.

Fig 2. Drum roasting of raw cashewnuts

This method is adopted in the factories where hand and leg operated shelling machines are used. The nuts after steam conditioned in a twin bottle type steaming unit for 20-25 minutes at 85 - 100 PSI. This process helps to loosen the kernel and make it amenable for shelling operation.

Fig 3. Steaming process for raw cashewnuts

(b) Oil bath roasting

Though it is an outdated method, few processing industries in Kerala and Karnataka are still following it. In this method raw nuts are passed for 1-3 minutes through a bath of heated CNSL maintained at a temperature of approximately 190-200°C by means of screw or belt conveyor. 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.

Shelling conditioned nuts

Nuts after roasting are shelled manually in most of the units in Kerala and Tamil Nadu. Manual shelling is requiring dexterity, wherein nuts are knocked 2-3 times on each of the long edge by a wooden mallet taking care to see that the whole kernels are released without damage or breakage as far as possible. The outturn will be 90 per cent of whole kernels. Individual workers' output is about 15-20 kg per 8 h working day. Workers smear ash or clay on their hands to avoid contact of corrosive shell oil with the skin. Due to air pollution, certain restrictions are imposed for this process.

Fig 4. Drum roasted nuts and manual cracking process

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. The pedal of the shelling unit is operated in such a way that nut it is held between two blades and lifting the lever by hand will split open the nut without damaging the kernel inside. Intact kernel is then scooped out by means of sharp needle.


Fig 5. Steamed nuts and shelling process

The output per worker per 8 hours shift in this method is estimated to be 14-22 kg of kernel. Semi- mechanized and automated shelling machines have been introduced in the line of processing to increase operational capacity.

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.


Fig 6. Borma dryer and Steam assisted cross flow dryer

Each tray can hold 10 kg of material to a depth of 5-7 cm, 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 10-30 min. The normal duration of heating is 6-12 h. Recently developed cross-

flow dryer has the capacity ranging from 250 – 1000 kg in a 8 h shift works at 80°C. The moisture content of the dried samples will be in the range of 1-2 per cent (d.b).

Peeling

Peeling is the operation of removal of the testa from the kernels. As the kernels are quite brittle after removal from the dryer, it needs to be cooled for 24-48 h for moisture infusion. A slight pressure applied through the fingers separates the testa. Sharp bamboo sticks or stainless-steel knife are also used to remove the adhering testa. The average peeling capacity is 7-10 kg/person/day. Pneumatic peelers are the recent introduction for bulk production which ranges from 60 kg to 250 kg per h.

Fig 7. Manual peeling of cashew kernels

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.

Fig 8. Kernel grading in operation

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. 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. At present, flexible packaging (Mould vacuum packaging) with nitrogen as inert gas is followed by majority of the cashew industries as tin container packaging is not accepted in the international trade.

Fig 9. Vita packing of cashew kernels

Quality standards

Standards for cashew kernels concerning the marketing and commercial quality control of food products moving in international trade is developed. The purpose of the standard is to define the quality requirements of the cashew kernels at the export control stage after preparation and packaging.

(a) Minimum requirement Free from any deterioration; Clean, practically free from any visible foreign matter; Free from mould or rancidity; Free from adhering testa and shell liquid; Free of any foreign smell or taste.

(b) Moisture content Cashew kernels shall have a moisture content equal to or more than 3% but not more than 5%.

(c) Classification

WHITE WHOLES	SCORCHED WHOLES	DESSERT WHOLES	WHITE PIECES	SCORCHED PIECES	DESSERT PIECES
WW-180 WW-210 WW-240 WW-320 WW-450 WW-500	SW-180 SW-210 SW-240 SW-320 SW-450 SW-500	SSW (Scorched Wholes Seconds) DW (Dessert wholes)	B (Butts) JH (Jumbo Half) S (Splits) LWP (Large White Pieces) SWP (Small White Pieces) BB (Baby Bits)	SS (Scorched Splits) SP (Scorched Pieces)	DP (Dessert Pieces)

Cashew Apple Processing and Value Addition

Rajkumar A.D.

Scientist (Food Technology)

ICAR-Directortae of Cashew Research, Puttur, Karnataka

Introduction:

Cashew apple is a tropical fruit rich in vitamins and minerals. The cashew apple contains 8-11 % of fermentable sugars and 260 to 340 mg/100 g of Vitamin C, which is almost six times that of citrus fruits (40 mg/100g) and almost ten times more than that of pineapple, an important tropical fruit. With a current annual cashew nut output of 7.28 lakh tonnes, cashew apple production in India is estimated as 60 lakh tonnes per annum (figures are subject to change); of which very little is consumed either as fresh fruit or in few cases processed into drinks or pulp, the rest gets wasted; because of its perishable nature. Considering the fact that cashew apples are harvested over a period of 4 -5 months during a year, its use as a raw material for a variety of fruit-based products can trigger revolution in cashew industry. This, apart from making cashew juice products available year round, will equalize supply from one year to another and will improve earnings from cashew for the farmers. Cashew apple can be processed as wine, gin, brandy, syrup, vinegar and jam some of which are being produced in commercial scale in Brazil, India and Mozambique. Cashew apple contains 85% juice, 10% of which is sugar.

1. Cashew apple Lime Blend RTS Nectar: "CASHLIME" A Functional Beverage

Cashew apple juice is sweet and nutritious, but has astringency due to the presence of tannins (0.2-0.3%), which makes it less palatable at the same time limits processing and marketability of its value added processed products. In order to overcome this problem attempts were made by compatibly blending the cashew apple juice with lime juice and by adding water. The threshold value for the sensation of astringency of tannins is 0.1%. Bellow this concentration astringency cannot be sensed. The concentration of cashew apple juice in the "Cashlime" is so adjusted that it will contribute maximum to the nutritional value of the product and naturally bring down the concentration of tannins bellow threshold value through optimum dilution with water. Blending with lime juice resulted in to delightful and delicious beverages with improved organoleptic quality and nutritive value as well. Keeping in view the nutritive and health benefits of cashew apple and lime, the present technology is developed where lime possess bland taste and cashew apple can serve as the best functional food by blending with lemon as taste improver. The product falls in the category of "Ready to Serve Nectar"

(RTS Nectar) beverage in food technological terms since the fresh fruit juice content of the beverage is more than 20%.

Methodology:

Out of eleven released varieties from DDT plot of this directorate, five varieties viz., Vengurla-3, Accession-301, Dhana, Bhaskara and Ullal-3 found to be suitable for the preparation of RTS beverage in terms of overall acceptability through organoleptic evaluation and biochemical composition. It is also concluded that the varieties having TSS more than 9^0Bx and tannin content less than 0.6% are suitable for making such beverage.

The fresh, well ripe and damage free cashew apples were collected, washed, followed by cutting in to 2-4 halves (stem end and nut end were discarded). The halves were fed to pulper/juicer and obtained pulp is strained in through screens/ 2-4 fold muslin cloth. Depending upon the extent of suspended particles the juice is allowed to settle for 2-4 hours preferably at refrigeration temperature (10^0C) or at room temperature. Leaving the sediments at the bottom the juice is decanted and used for product preparation. Similarly the lime juice is obtained from fresh and firm yellow lemons. To make out the difference in the palatability and overall acceptance, a control sample product was prepared from the cashew apple juice only and compared with the RTS prepared by blending lime juice with different levels of concentration keeping cashew apple juice content same in all the preparations. To overcome the little flat aftertaste all the formulations were added with 0.250g citric acid per litre of the cashew apple juice. The concentration of citric acid was determined by conducting a small trial of experiments. The final quantity of the RTS was made by adding sugar (10^0Bx) and water as per the recipe and the mixture was pasteurized and filled in PET bottles with food grade colour and 70 ppm KMS as a preservative. The product prepared from formula E (Sample E, Table 1) was found superior after conducting organoleptic evaluation based on 9 point hedonic scale (Fig.1). The exact recipe of the product preparation will be disclosed as per the directions of ITMU/ITMC.

The prepared and organoleptically proven best combination of cashew apple- lime blend RTS was analyzed for its nutritive value. The product which stood best among the different combinations was analyzed for its nutritive value and antioxidant activity (Table 2). Antioxidant activity of fresh cashew apple juice, cashew apple lime juice blend RTS, RTS from cashew apple juice only and one commercial same category beverage named “nimbooz” for comparision was determined by DPPH scavenging assay (Das *et al*. 1988). The concentration of phenolics and tannins in the juice

was determined using spectrophotometric (Folin-Ciocalteu's) method (Singleton *et al*., 1999).TSS of the juices was determined by hand refractometer (ERMA). Vitamin C content was measured by 2,6-Dichlorophenol – Indophenol visual titration method (Ranganna,2000).

Table 1. Organoleptic evaluation of Cashew apple- Lime blend RTS

Sample Code	Colour	Flavour	Astringency	Taste	Overall Acceptability
A (Only CA Juice)	3.9	4.5	5.4	4.9	4.5
B	4.9	5.1	5.7	5.0	5.0
C	4.7	4.4	5.4	5.7	5.2
D	6.2	6.4	6.7	7.0	6.4
E	7.6	7.6	7.8	8.2	7.9
F	6.1	6.2	6.4	6.6	6.4
SEd	0.5538	0.4480	0.5544	0.4753	0.3839
CD (.05)	1.1103	0.8983	1.1116	0.9530	0.7697
CD(.01)	1.4796	1.1971	1.4814	1.2700	1.0258
CV%	22.24	17.58	19.89	17.05	14.55

(Nine point hedonic scale where, score 1: Disliked Extremely; 9: Liked Extremely)

Health Beverage:

Ascorbic acid is an important nutrient for the human physiology, and it has a role in the production and maintenance of collagen, wound healing, and the reduction in susceptibility to infections, formation of bones and teeth, iron absorption and prevention of scurvy. Phenolic compounds are metabolites that have the ability to neutralize reactive species, helping to protect the body against oxidative stress and have antioxidant activity. Cashew apple juice is a rich source of both of these functional nutrients having nutracuiticals properties which in turn makes the product a functional one, unlike traditional fruit drinks.

Nutrient value:

It is clearly understood that the RTS prepared from the selected combination of Juices was superior over that of from cashew apple juice only. The product could retain maximum of ascorbic acid (75.9 mg/100ml), total phenolics (0.06%). The tannin content (86.62mg/100ml) of the product was found bellow threshold level of sensation of astringency (≤0.1%) , at this concentration the

product won't give an astringent taste. Presence of sufficient amount of ascorbic acid, tannins and phenolics made the product more functional than the traditional one, DPPPH scavenging activity of the selected combination (sample-E) was greater (281.6 µmoles/15min/100 µl juice) than the product prepared only from cashew apple juice (203.8 µmoles/15min/100 µl juice). This is attributed to additional antioxidants in the product due to the presence of extra 3% lime juice unlike the control. The other proximate chemical components of the juices are mentioned in following table.

Table 2. Nutritional value and functional properties of the product compared with fresh juice and RTS without lime juice

Sl.No.	Parameter	Raw Juice	RTS Without Lime Juice	Cashew Apple-Lime Blend RTS	Commercial Lime RTS (Nimbooz)
1.	TSS (^{0}Bx)	11.5	10.0	10.0	10.0
2.	Ascorbic acid (mg/100ml)	330.0	68.0	75.9	13.2
3.	Tannin (mg/100ml)	289.0	90.86	86.62	3.7
4.	Total phenol (%)	0.28.0	0.04	0.06	0.02
5.	DPPH Scavenging Activity (µmoles/15min/100 µl juice)	1184.2	203.8	281.6	117.0
6.	Acidity (%)	0.48	0.33	0.38	0.46
7.	Carbohydrates (%)	14.05	13.02	13.06	13.0
8.	Sugars (%)	12.04	11.04	12.06	12.02
9.	Protein (%)	0.18	----	----	----
10.	Fat (%)	0.09	----	----	----
11.	Energy (Kcal/100ml)	51	47	51	50

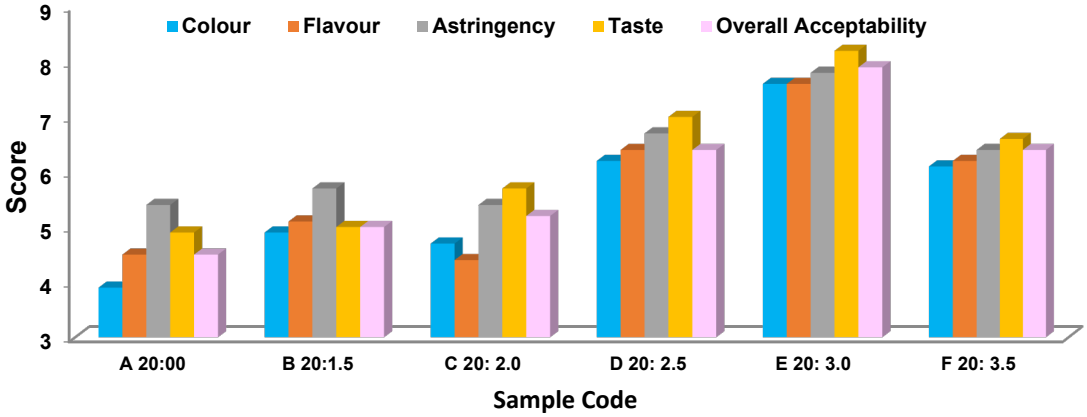


Fig.1. Organoleptic Evaluation of Cashew apple- Lime Blend RTS

Major Requirements of Processing Plant Establishment
Cottage Scale: (≤ 200 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	A Room	12X16 ft
2.	Potable water supply	24x7
3.	Power/ electric supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	20 in number
5.	Deep SS Pans (50 L capacity) for apples washing and Juice making	3 in number
6.	Deep SS Pans (20 L capacity) Miscellaneous work	3 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	10 in number
8.	Sharp Knives for fruit Cutting: minimum	10 in number
9.	Heavy Duty Fruit processor/ Mixer Grinder	Three in number
10.	Muslin cloth/ Filter cloth	Min. 2 meters per day

11.	Packaging Material:	PET bottles as per requirement depending upon filling size
12.	Plungers, Spoons and raw material storage boxes	As required
13.	Labor	Min 3/ Max 5

Major Requirements of Processing Plant Establishment
Large Scale: (≥ 1000 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	Plant	2000sq ft
2.	Potable water supply	24x7
3.	Power/ electric supply/ boiler heat supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	minimum 100 in number
5.	Steam Jacketed/ heating Kettles (150-200 L capacity)	Three in number
6.	Deep SS Pans (50 L capacity) Miscellaneous work	minimum 10 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	minimum 50 in number
8.	Fruit Juice (100 kg fruit per hour capacity)	one/two
9.	Packaging Material:	PET bottles as per requirement depending upon filling size

Waste Utilisation:
The pomace remaining behind can be used for/as:

1. Poultry/Cattle feed
2. Compost
3. With sophisticated technology further it can be used in foods like Bakery products

Training:
At a time ten people can be trained at laboratory scale for this technology Commercialization

Cost of Technology: Tentative estimation of technology cost*

Sl. No.	Particulars	Time in months	Cost/ salary incurred (Rs.)
1.	Total scientific man months	3 months	130,000.00
2.	Technical (contractual) man power months	1.5 months	18,000.00
3.	Travel expenses	--	5,000.00
4.	Power/ fuel input	--	6,000.00
5.	Raw material input	--	15,000.00
			Total: 174,000.00

* Added to this the final license fees/ technology cost and its sale based on either exclusive or nonexclusive licensing will be decided by the ITMU/ITMC.

2. Cashew Apple Cider: An Antioxidant Rich Functional Food

Cashew apple cider is prepared from four different varieties separately (Dhana, Madakathara-2, V-4, NRCC-301) out of eleven screened and also from mixed variety cashew apple juice through anaerobic fermentation at room temperature by yeast *Saccharomyces cerevisiae*. Other varieties may also result in to a good quality product. Any variety rich in sugars, tannins and phenols will be suitable for the cider making. The pH (4.2-4.4) for the efficient fermentation was identified and maintained by using suitable buffers at different stages of fermentation. The sugar is added to the tune of 1-2% if the TSS of fresh juice is bellow 10^0Bx. The alcohol content of the product is in the range of 3.5-6.0 % v/v As per the preliminary sensory analysis of the prepared product the one prepared from mixed juices was found to be superior attributed to contribution of flavor characteristics by different unidentified unique constituents of each variety.

The prepared product analyzed for polyphenols and other antioxidants as in the case of grape wine. Presence of these nutrients adds to the therapeutic value of the product. The cider prepared was observed for its stability with respect to its sensory attributes (colour and flavour) and few chemical changes during storage. It is observed that the product below 3.5 % residual sugar content do not undergo significant change in its sensory and chemical attributes whereas if residual TSS is more than 4% surface scum formation and colour darkening was evident. Cider prepared from NRCC -301 has a positive appeal towards its colour characteristics owing to ability to retain red colour of skin in the juice unlike other varieties.

Methodology:

Out of eleven released varieties from DDT plot of this directorate, five varieties viz., Bhaskara, NRC-301, Dhana, Madakathara-2, V-4 and mixed variety juice was found to be suitable based on their Biochemical composition and subsequent sensory quality of the product (Table No. 1).

Table 1 : Alcohol content of cider from different varieties based on TSS

Variety	**TSS Before Fermentation (^{0}Bx)**	**TSS Before Fermentation (^{0}Bx)**	**Alcohol Content (%v/v)**
Dhana	9.0	1.0	4.20
Madakathara-2	10.0	1.5	4.74
V-4	9.5	1.7	4.11
NRCC-301	11	1.5	5.03
Bhaskara	8.5	2.0	3.42
Mixed Juice	10.2	1.5	4.60

The fresh, well ripe, firm and damage free cashew apples from selected varieties were collected, washed, followed by cutting in to 2-4 halves (stem end and nut end were discarded). The halves were fed to pulper and obtained pulp is either used directly for the jelly preparation of stored at frozen temperature for future use. The prepared pulp was then filtered through double layered muslin cloth. The juice obtained was heated to60-62^{0}C (inactivation of enzymes and mesophilic microorganisms). The inoculums (standardised) of yeast is prepared in 100ml of preheated and cooled (38-40^{0}C) cashew apple juice with addition of 1% table sugar for early activation of yeast cells from the active dry yeast obtained from market. Prepared inoculums is then added to the pre heated and cooled (38-40^{0}C) juice in the fermentor and the fermentor is kept open for pre decided time and then closed to create anaerobic conditions for the efficient fermentation of sugars in to alcohol. An air lock is used to discharge the CO2 released during fermentation. Fermentation progress is monitored intermittently by checking the TSS and pH of the infusion.

The fermentation completes in 5 to 6 days and a result of which the yeast cells settles all the way at the bottom of the fermentor. The fement is then decanted without disturbing the sediments of yeast cells followed by pasteurisation at 56-58^{0}C to inactivate the yeast cells in the cider. The product

so prepared is then filled in to the umber coloured glass/ PET bottles, sealed and stored in refrigerator/cool place. Based on the nutrient composition of the product during storage the shelf life of cashew apple cider is estimated to be 6 months at room temperature and 9-12 months when stored at refrigeration temperature. (https://www.mpi.govt.nz/dmsdocument/12540-how-to-determine-the-shelf-life-of-food-guidance-document). The exact recipe of the product preparation will be disclosed as per the directions of ITMU/ITMC.

The prepared jelly was analyzed for its nutritive value. Antioxidant activity of the jelly was determined by DPPH scavenging assay (Das *et al*. 1988). The concentration of phenolics and tannins in the jelly was determined using spectrophotometric (Folin-Ciocalteu's) method (Singleton *et al*., 1999).TSS of the jm was determined by hand refractometer (ERMA). Vitamin C content was measured by 2,6- Dichlorophenol – Indophenol visual titration method (Ranganna,2000).

Functional Beverage:

Ascorbic acid is an important nutrient for the human physiology, and it has a role in the production and maintenance of collagen, wound healing, and the reduction in susceptibility to infections, formation of bones and teeth, iron absorption and prevention of scurvy. Phenolic compounds are metabolites that have the ability to neutralize reactive species, helping to protect the body against oxidative stress and have antioxidant activity. Cashew apple cider is a rich source of both of these functional nutrients having nutracuiticals properties which in turn makes the product a functional one, unlike traditional fruit drinks.

Nutrient value:

Table 3. Nutritional value and functional properties of Cashew Apple Cider

Sl.No.	Parameter	Value
1.	TSS (^{0}Bx)	1-1.5
2.	Ascorbic acid (mg/100ml)	150-220
3.	Tannin (mg/100ml)	112-186
4.	Total phenol (mg/100ml)	140-205
5.	Antioxidant activity (CUPRAC) (mg/100ml)	65-100

6.	Antioxidant activity FRAP (mg/100ml)	250-400
7.	Carbohydrates (%)	1.5-2.0
8.	Sugars (%)	1-1.5
9.	Ethanol (%)	3.5-6
10.	Protein (%)	---
11.	Fat (%)	---
12.	Energy (Kcal/100ml)	40-50

Major Requirements of Processing Plant Establishment
Cottage Scale: (≤ 200 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	A Room	12X16 ft
2.	Potable water supply	24x7
3.	Power/ electric supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	20 in number
5.	Deep SS Pans (50 L capacity) for apples washing and Juice making	3 in number
6.	Deep SS Pans (20 L capacity) Miscellaneous work	3 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	10 in number
8.	Sharp Knives for fruit Cutting: minimum	10 in number
9.	Heavy Duty Fruit processor/ Mixer Grinder	Three in number
10.	Biostatic Fermentor (250L/Day)	1
11.	Muslin cloth/ Filter cloth	Min. 2 meters per day
12.	Packaging Material:	Umber colored glass/PET bottles depending upon filling size
13.	Plungers, Spoons and raw material storage boxes	As required
14.	Labour	Min. 3-Max.5

Major Requirements of Processing Plant Establishment
Large Scale: (1000 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	Plant	2000sq ft
2.	Potable water supply	24x7
3.	Power/ electric supply/ boiler heat supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	minimum 100 in number
5.	Steam Jacketed/ heating Kettles (150-200 L capacity)	Three in number
6.	Deep SS Pans (50 L capacity) Miscellaneous work	minimum 10 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	minimum 50 in number
8.	Fruit Juicer (100 kg fruit per hour capacity)	one/two
9.	Biostatic Fermentor (1000 L/Day)	1
9.	Packaging Material:	Umber colored glass/PET bottles depending upon filling size

Training:
At a time five people can be trained at laboratory scale for this technology commercialization

Cost of Technology: Tentative estimation of technology cost*

Sl. No.	Particulars	Time in months	Cost/ salary incurred (Rs.)
1.	Total scientific man months	10 months	500,000.00
2.	Technical (contractual) man power months	2 months	24,000.00
3.	Travel expenses	--	5,000.00
4.	Power/ fuel input	--	6,000.00
5.	Raw material input	--	15,000.00
			Total: 550,000.00

* Added to this the final license fees/ technology cost and its sale based on either exclusive or nonexclusive licensing will be decided by the ITMU/ITMC.

3. Cashew Apple Jam: An Antioxidant Rich Functional Food

Though only eleven released varieties were considered for screening but there is every chance that other varieties or accessions we may find suitable for the preparation of jam and jelly depending upon its chemical composition and most importantly the pectin content. Pectin content of cashew apple is very low as compared to other fruits which are preferred for jam and jelly making (Table 1). Hence need of external source of pectin becomes crucial to set a quality jam. In view of that the suitable concentration of commercial pectin was worked out to set a jam and part of it was replaced by a natural source of pectin i.e. dried orange peel powder extract (Boiled).

Table 1: Pectin Content of various fruits in comparison with cashew apple

Sl.No.	Fruit	Pectin (%)	pH	Acidity (%)
1.	Apple	0.7	3.2-3.5	0.52
2.	Sweet Cherry	0.36	3.4-3.7	1.36
3.	Plums	0.76	3.1-3.4	2.21
4.	Peaches	0.54	3.4-3.8	0.62
5.	Straw berries	0.81	3.2-3.5	1.11
6.	Cashew Apple	0.24	4.2-4.4	0.42

Methodology:

Out of eleven released varieties from DDT plot of this directorate, three varieties viz., Bhaskara, NRC-301, and VTH-174 found to be suitable based on their pectin content (Table 2) for the preparation of jam. Though only three released varieties were considered suitable out of eleven screened, but there is every chance that some more other varieties or accessions we may find suitable for the preparation of jam.

Table 2: Cashew apple pectin content of different released varieties

Sl.No.	Variety	Colour	TSS (^{0}B)	Acidity (%)	Pectin (%)
1	Bhaskara	Red	9	0.43	0.19
2	Madakkathara - 2	Red	10	0.59	0.09
3	Ullal-3	Red	10.5	0.29	0.1
4	Vengurla -4	Red	9.5	0.37	0.12
5	NRC-301	Red	9	0.27	0.17
6	NRCC Selection-2	Red	11	0.48	0.07
7	Dhana	Yellow	9	0.4	0.09
8	Priyanka	Yellow	10.5	0.41	0.09
9	VTH-174	Yellow	11.5	0.52	0.24
10	Kanaka	Yellow	12	0.39	0.14
11	Vengurla-3	Yellow	10.5	0.4	0.15

The fresh, well ripe, firm and damage free cashew apples from selected varieties were collected, washed, followed by cutting in to 2-4 halves (stem end and nut end were discarded). The halves were fed to pulper and obtained pulp is either used directly for the jam preparation of stored at frozen temperature for future use. The pulp is then kept in deep SS pan or in a steam jacketed kettle for boiling with timely addition of sugar, acid, commercial pectin, natural source of pectin (dried orange peel powder extract) and permitted edible colour as per the recipe standardised. The infusion is heated till the TSS reaches to 68.5 - 70^0 Bx or till the temperature of infusion reaches to 105^{0}C (cooking end point). The hot preparation is then filled in glass jars at around 60-70^{0}C (hot filling) or at 55-60^{0}C in PET jars. The product is self stable at room temperature (six months) but should be kept in cool and dry places to preserve its organoleptic properties. The exact recipe of the product preparation will be disclosed as per the directions of ITMU/ITMC.

The prepared jam was analyzed for its nutritive value. Antioxidant activity of the jam was determined by DPPH scavenging assay (Das *et al*. 1988). The concentration of phenolics and tannins in the jam was determined using spectrophotometric (Folin-Ciocalteu's) method (Singleton *et al*., 1999).TSS of the jm

was determined by hand refractometer (ERMA). Vitamin C content was measured by 2,6-Dichlorophenol – Indophenol visual titration method (Ranganna,2000).

Functional Food:

Ascorbic acid is an important nutrient for the human physiology, and it has a role in the production and maintenance of collagen, wound healing, and the reduction in susceptibility to infections, formation of bones and teeth, iron absorption and prevention of scurvy. Phenolic compounds are metabolites that have the ability to neutralize reactive species, helping to protect the body against oxidative stress and have antioxidant activity. Cashew apple jam is a rich source of both of these functional nutrients having nutracuiticals properties which in turn makes the product a functional one, unlike traditional fruit drinks.

Nutrient value:

The product could retain maximum of ascorbic acid (121 mg/100ml), total phenolics (134 mg/100ml). The tannin content (112 mg/100ml) of the product was found bellow threshold level of sensation of astringency (≤0.1%) and higher concentration of sugar in the product also mask the astringency if present to some extent. Presence of sufficient amount of ascorbic acid, tannins and phenolics made the product more functional than the traditional one. High antioxidant activities recorded by CUPRAC assay (403mg/100ml) and by FRAP assay (200 mg/100ml). This is attributed to the presence of high level of vitamin C and phenolics in the cashew apple juice. The other proximate chemical components and nutritional facts in comparison with a market jam (Kisaan Mixed Fruit Jam) are mentioned in following Table No. 2 where it can be clearly understood that the cashew apple jam is nutritionally superior over the market jam.

Table 3. Nutritional value and functional properties of Cashew Apple Jam

Sl.No.	Parameter	CA Jam	Kisaan Mix Fruit Jam
1.	TSS (^{0}Bx)	68.5	Not Determined
2.	Ascorbic acid (mg/100ml)	121.0	
3.	Tannin (mg/100ml)	112.0	
4.	Total phenol (mg/100ml)	134.0	

5.	Antioxidant activity (CUPRAC) (mg/100ml)	403.0	
6.	Antioxidant activity FRAP (mg/100ml)	200.0	
7.	Carbohydrates (%)	69.0	70.5
8.	Sugars (%)	68.7	69.0
9.	Dietary Fiber (%)	1.6	1.0
10.	Protein (%)	0.17	---
11.	Fat (%)	0.12	---
12.	Energy (Kcal/100g)	277	285

Major Requirements of Processing Plant Establishment
Cottage Scale: (≤ 200 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	A Room	12X16 ft
2.	Potable water supply	24x7
3.	Power/ electric supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	20 in number
5.	Deep SS Pans (50 L capacity) for apples washing and Juice making	3 in number
6.	Deep SS Pans (20 L capacity) Miscellaneous work	3 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	10 in number
8.	Sharp Knives for fruit Cutting: minimum	10 in number
9.	Heavy Duty Fruit processor/ Mixer Grinder	Three in number
10.	Muslin cloth/ Filter cloth	Min. 2 meters per day
11.	Packaging Material:	Glass Jar or PET jars as per requirement depending upon filling size
12.	Plungers, Spoons and raw material storage boxes	As required

Major Requirements of Processing Plant Establishment
Large Scale: (1000 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	Plant	2000sq ft
2.	Potable water supply	24x7
3.	Power/ electric supply/ boiler heat supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	minimum 100 in number
5.	Steam Jacketed/ heating Kettles (150-200 L capacity)	Three in number
6.	Deep SS Pans (50 L capacity) Miscellaneous work	minimum 10 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	minimum 50 in number
8.	Fruit Juice (100 kg fruit per hour capacity)	one/two
9.	Packaging Material:	Glass Jar or PET jars as per requirement depending upon filling size

Training:
At a time five people can be trained at laboratory scale for this technology commercialization

Cost of Technology: Tentative estimation of technology cost*

Sl. No.	Particulars	Time in months	Cost/ salary incurred (Rs.)
1.	Total scientific man months	4 months	200,000.00
2.	Technical (contractual) man power months	2 months	24,000.00
3.	Travel expenses	--	5,000.00
4.	Power/ fuel input	--	6,000.00
5.	Raw material input	--	15,000.00
			Total: 250,000.00

* Added to this the final license fees/ technology cost and its sale based on either exclusive or nonexclusive licensing will be decided by the ITMU/ITMC.

4. Cashew Apple Jelly: An Antioxidant Rich Functional Food

Though only eleven released varieties were considered for screening but there is every chance that other varieties or accessions we may find suitable for the preparation of jelly depending upon its chemical composition and most importantly the pectin content. Pectin content of cashew apple is very low as compared to other fruits which are preferred for jelly making (Table 1). Hence need of external source of pectin becomes crucial to set a quality jelly. In view of that the suitable concentration of commercial pectin was worked out to set a jelly and part of it was replaced by a natural source of pectin i.e. cooked guava (unripe/firm) pulp extract was added at different level of concentration and a suitable concentration is fixed to set a quality jelly.

Table 1 : Pectin Content of various fruits in comparison with cashew apple

Sl.No.	Fruit	Pectin (%)	pH	Acidity (%)
1.	Apple	0.7	3.2-3.5	0.52
2.	Sweet Cherry	0.36	3.4-3.7	1.36
3.	Plums	0.76	3.1-3.4	2.21
4.	Peaches	0.54	3.4-3.8	0.62
5.	Straw berries	0.81	3.2-3.5	1.11
6.	Cashew Apple	0.24	4.2-4.4	0.42

Methodology:

Out of eleven released varieties from DDT plot of this directorate, three varieties viz., Bhaskara, NRC-301, and VTH-174 found to be suitable based on their pectin content (Table 2) for the preparation of jelly. The product can also be prepared from any other varieties with addition of commercial pectin or natural source of pectin at the rate of 0.1 to 0.5 % (depending upon the original pectin content of cashew apple) more than the selected varieties.

Table 2: Pectin content of Cashew apples of different released varieties

Sl.No.	Variety	Colour	TSS (^{0}B)	Acidity (%)	Pectin (%)
1	Bhaskara	Red	9	0.43	0.19
2	Madakkathara - 2	Red	10	0.59	0.09
3	Ullal-3	Red	10.5	0.29	0.1
4	Vengurla -4	Red	9.5	0.37	0.12
5	NRC-301	Red	9	0.27	0.17
6	NRCC Selection-2	Red	11	0.48	0.07
7	Dhana	Yellow	9	0.4	0.09
8	Priyanka	Yellow	10.5	0.41	0.09
9	VTH-174	Yellow	11.5	0.52	0.24
10	Kanaka	Yellow	12	0.39	0.14
11	Vengurla-3	Yellow	10.5	0.4	0.15

The fresh, well ripe, firm and damage free cashew apples from selected varieties were collected, washed, followed by cutting in to 2-4 halves (stem end and nut end were discarded). The halves were fed to pulper and obtained pulp is either used directly for the jelly preparation of stored at frozen temperature for future use. The pulp is then kept in deep SS pan or in a steam jacketed kettle for boiling with timely addition of sugar, acid, commercial pectin, natural source of pectin (dried orange peel powder extract) and permitted edible colour as per the recipe standardised. The infusion is heated till the TSS reaches to 65^0 Bx or till the temperature of infusion reaches to 105^0C (cooking end point). The hot preparation is then filled in glass jars at around 60-70^0C (hot filling) or at 55-60^0C in PET jars. The product is self stable at room temperature (six months) but should be kept in cool and dry places to preserve its organoleptic properties (https://www.mpi.govt.nz/dmsdocument/12540-how-to-determine-the-shelf-life-of-food-guidance-document). The exact recipe of the product preparation will be disclosed as per the directions of ITMU/ITMC.

The prepared jelly was analyzed for its nutritive value. Antioxidant activity of the jelly was determined by DPPH scavenging assay (Das *et al*. 1988). The concentration of phenolics and tannins

in the jelly was determined using spectrophotometric (Folin-Ciocalteu's) method (Singleton *et al*., 1999).TSS of the jm was determined by hand refractometer (ERMA). Vitamin C content was measured by 2,6- Dichlorophenol – Indophenol visual titration method (Ranganna,2000).

Functional Food:

Ascorbic acid is an important nutrient for the human physiology, and it has a role in the production and maintenance of collagen, wound healing, and the reduction in susceptibility to infections, formation of bones and teeth, iron absorption and prevention of scurvy. Phenolic compounds are metabolites that have the ability to neutralize reactive species, helping to protect the body against oxidative stress and have antioxidant activity. Cashew apple jelly is a rich source of both of these functional nutrients having nutracuiticals properties which in turn makes the product a functional one, unlike traditional fruit drinks.

Nutrient value:

The product could retain maximum of ascorbic acid (121 mg/100ml), total phenolics (134 mg/100ml). The tannin content (112 mg/100ml) of the product was found bellow threshold level of sensation of astringency (≤0.1%) and higher concentration of sugar in the product also mask the astringency if present to some extent. Presence of sufficient amount of ascorbic acid, tannins and phenolics made the product more functional than the traditional one. High antioxidant activities recorded by CUPRAC assay (403mg/100ml) and by FRAP assay (200 mg/100ml). This is attributed to the presence of high level of vitamin C and phenolics in the cashew apple juice. The other proximate chemical components and nutritional facts in comparison with a market jelly (Kisaan Mixed Fruit Jam) are mentioned in following Table No. 2 where it can be clearly understood that the cashew apple jelly is nutritionally superior over the market jelly.

Table 3. Nutritional value and functional properties of Cashew Apple Jelly

Sl.No.	Parameter	CA Jelly	Kisaan Mix Fruit Jam
1.	TSS (^{0}Bx)	65.0	Not Determined
2.	Ascorbic acid (mg/100ml)	142.0	
3.	Tannin (mg/100ml)	93.0	
4.	Total phenol (mg/100ml)	117.0	
5.	Antioxidant activity (CUPRAC) (mg/100ml)	316.0	
6.	Antioxidant activity FRAP (mg/100ml)	152.0	
7.	Carbohydrates (%)	66.0	70.5
8.	Sugars (%)	65.5	69.0
9.	Dietary Fiber (%)	Traces*	1.0
10.	Protein (%)	0.06	---
11.	Fat (%)	0.08	---
12.	Energy (Kcal/100g)	261	285

*Since the product is prepared from strained cashew apple juice the dietary fiber content is very low

Major Requirements of Processing Plant Establishment
Cottage Scale: (≤ 200 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	A Room	12X16 ft
2.	Potable water supply	24x7
3.	Power/ electric supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	20 in number
5.	Deep SS Pans (50 L capacity) for apples washing and Juice making	3 in number
6.	Deep SS Pans (20 L capacity) Miscellaneous work	3 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	10 in number

8.	Sharp Knives for fruit Cutting: minimum	10 in number
9.	Heavy Duty Fruit processor/ Mixer Grinder	Three in number
10.	Muslin cloth/ Filter cloth	Min. 2 meters per day
11.	Packaging Material:	Glass Jar or PET jars as per requirement depending upon filling size
12.	Plungers, Spoons and raw material storage boxes	As required
13.	Labor	Min 3/ Max 5

Major Requirements of Processing Plant Establishment
Large Scale: (1000 L per day)

Sl. No.	Particulars	Quantity required (Minimum)
1.	Plant	2000sq ft
2.	Potable water supply	24x7
3.	Power/ electric supply/ boiler heat supply	24x7
4.	Plastic Crates (20Kg capacity) for fruit collection and waste disposal	minimum 100 in number
5.	Steam Jacketed/ heating Kettles (150-200 L capacity)	Three in number
6.	Deep SS Pans (50 L capacity) Miscellaneous work	minimum 10 in number
7.	Aluminum or SS Trays (2X4 ft) for fruit Cutting	minimum 50 in number
8.	Fruit Juice (100 kg fruit per hour capacity)	one/two
9.	Packaging Material:	Glass Jar or PET jars as per requirement depending upon filling size

Training:
At a time five people can be trained at laboratory scale for this technology commercialization

Cost of Technology: Tentative estimation of technology cost*

Sl. No.	Particulars	Time in months	Cost/ salary incurred (Rs.)
1.	Total scientific man months	4 months	200,000.00
2.	Technical (contractual) man power months	2 months	24,000.00
3.	Travel expenses	--	5,000.00
4.	Power/ fuel input	--	6,000.00
5.	Raw material input	--	15,000.00
			Total: 250,000.00

* Added to this the final license fees/ technology cost and its sale based on either exclusive or nonexclusive licensing will be decided by the ITMU/ITMC.

Overview of Global Cashew Scenario & India's Future Forward

C.P. APPANNA
(EX-General Manager, NABARD)
Agri-Project advisor & Consultant

Cashew-World Scenario-Background

Cashew (A. occidentale L.) is native to Latin America and has a primary center of diversity in Amazonia, and a secondary one in the Planalto of Brazil. Natural occurrence of cashew has been reported from Mexico to Peru, and in the West Indies. It was one of the first fruit trees from the New World to be widely distributed throughout the tropics by the early Portuguese and Spanish adventurers. The name cashew is from the Portuguese caju, which in turn comes from the Tupi-Indian word acaju. The incoming colonists in what is now Brazil found that the native Indians valued both the cashew nut and the so-called apple, the fleshy pedicel or stalk of the fruit (Deckers et al., 2001). Cashew was discovered by Portuguese traders and explorers in Brazil in 1578. It was introduced into West and East Africa and India by the Portuguese travelers in the 16th century. By then, cashew was considered a suitable crop for soil conservation, forestation, and also wasteland development. Therefore, the initial aim of cashew introduction to those areas was not to produce nuts and apples (pseudo-fruits), but to help control soil erosion on the coast (Bradtke, 2007). Use of cashew nuts and apples developed much later, and the international nut trade did not start until the 1920s (Rieger, 2006). Thereafter, cashew gradually gained commercial importance and spread in other places. It is now naturalized in many tropical countries, particularly in coastal areas of East Africa (Tanzania, Kenya, Mozambique, Madagascar and Uganda), West and Central Africa (Ivory Coast, Nigeria and Angola), Florida, Peru, Hawaii, Tahiti, Mauritius, Seychelles, Panama, India, Sri Lanka, Thailand, Malay Peninsula and Philippine. The cashew industry ranks third in the world production of edible nuts with world production in 2000 at about 2 million tonnes of nuts-in-shell and an estimated value in excess of US$2 billion. India and Brazil are the major cashew exporters, with 60 percent and 31 percent respectively of world market share. The major importers are the United States (55 percent), the Netherlands (ten percent), Germany (seven percent), Japan (five percent) and the United Kingdom (five percent). Cashew kernels are ranked as either the second or third most expensive nut traded in the United States. Macadamia nuts are priced higher and pecan nuts can be more costly, if the harvest is poor. The extensive market connections of exporters from Brazil and India make it difficult for the smaller exporters to make gains in the United States market. Importers may appreciate the low prices offered by small suppliers, but the lack of reliability in quality tends to make them favors the larger, more reputable suppliers.

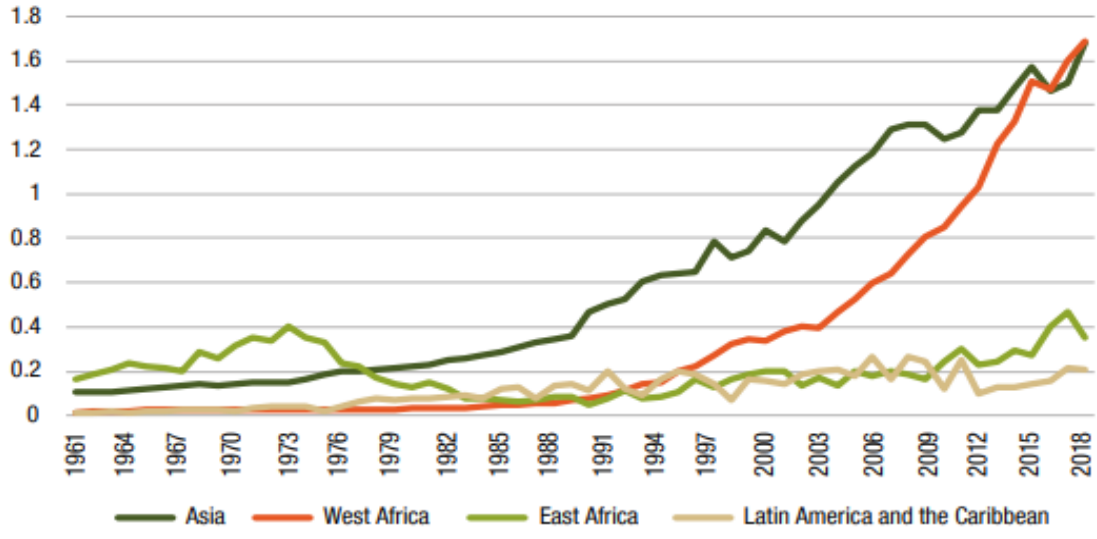
Cashew-growing countries by region

Region	Country	
Africa (20)	Angola*	Kenya
	Benin*	Madagascar*
	Burkina Faso*	Malawi*
	Cameroon	Mali*
	Côte d'Ivoire	Mozambique*
	Gabon	Nigeria
	Gambia*	Senegal*
	Ghana	Sierra Leone*
	Guinea*	Togo*
	Guinea-Bissau*	United Republic of Tanzania*
Asia (12)	Bangladesh*	Malaysia
	Cambodia*	Myanmar*
	China	Philippines
	India	Sri Lanka
	Indonesia	Thailand
	Lao People's Democratic Republic*	Viet Nam
Latin America and the Caribbean (14)	Belize	Jamaica
	Bolivia (Plurinational State of)	Nicaragua
	Brazil	Mexico
	Colombia	Panama
	Costa Rica	Peru
	Dominican Republic	Suriname
	Honduras	Venezuela (Bolivarian Republic of)

* Least developed country

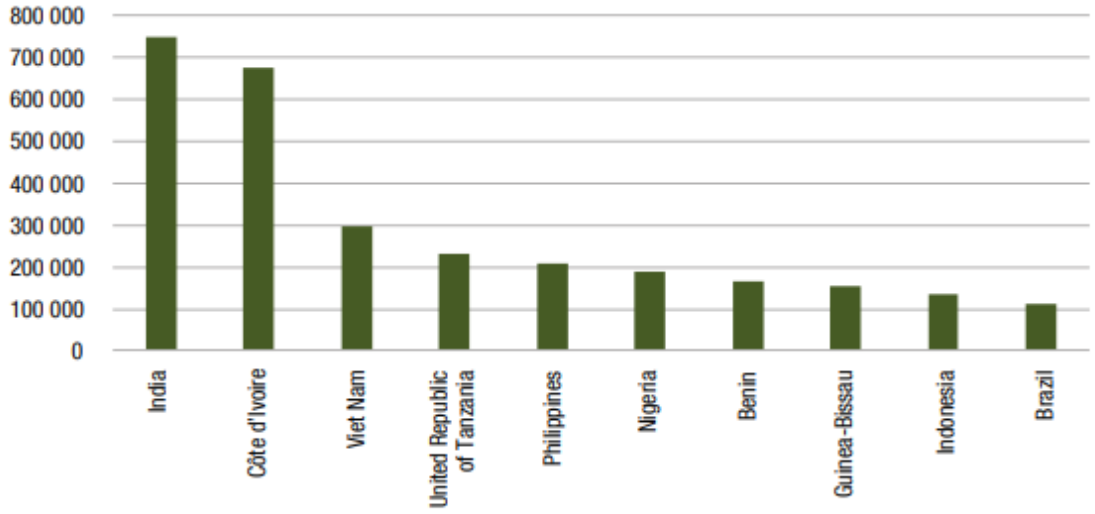
Source: UNCTAD, based on data from the United Nations Comtrade database and FAOstat.

Raw cashew nut production by region
(Millions of tons)



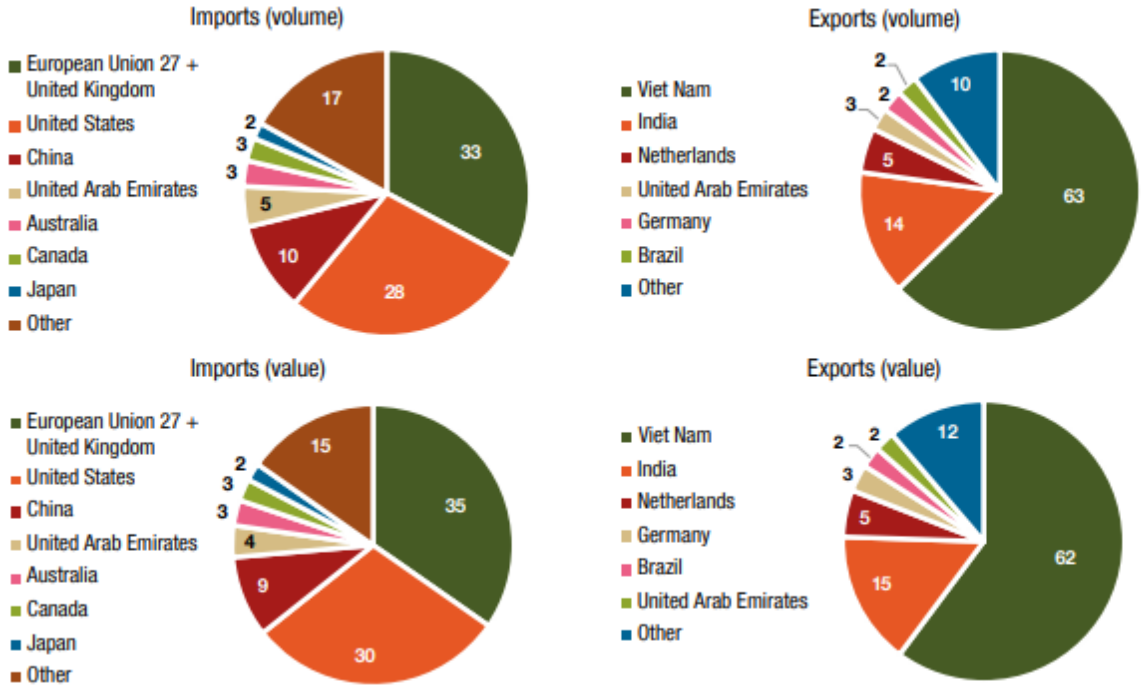
Source: UNCTAD calculations, based on data from Comtrade, DCCD, FAOstat, the General Department of Viet Nam Customs and Viet Nam statistical yearbooks.

Top 10 raw cashew nut producing countries, average production 2014–2018
(Tons)



Source: UNCTAD calculations, based on data from Comtrade, DCCD, FAOstat, the General Department of Viet Nam Customs and Viet Nam statistical yearbooks.

Global cashew kernel trade shares, average 2015–2019
(Percentage)



Source: UNCTAD calculations, based on data from Comtrade and the General Department of Viet Nam Customs.

Cashew in Africa

Africa produces 42% of the estimated 2.6 million tonnes of raw cashews every year. Of this, it exports 90% to the rest of the world, retaining the rest for domestic produce. In the recent past, while most of the efforts were aimed at improving farm level productivity through seed programmes, replantation and rejuvenation, training and capacity building on farm management practices etc., a lot has also been done on reforming markets and revitalizing institutional infrastructure too. Tanzania, through the Cashew Board of Tanzania, has put in place a robust warehouse receipt-based auction system to ensure quality nuts get fair price and small-holder farmers are not discriminated against. This has been working very well. Further, the Cashew Board of Tanzania is going ahead with establishment of three processing plants under public-private partnership model with the involvement of producer cooperative and government. Like-wise, Cote d'Ivoire, through its regulatory body, the Cotton and Cashew Council (CCC), sealed raw cashew movement through the land route and restricted raw cashew exports only through Abidjan and San Padro ports to bring in accountability. Besides, it fixed a minimum price for raw cashew for 2014 season and ensured farmers do not sell below it. Cote d'Ivoire with its significant production volume thus brought in necessary discipline in the raw cashew trade and exports. Simultaneously, CCC have started engaging with Vietnam at government to government to level to get access to Vietnam cashew processing technology into Cote d'Ivoire in exchange for assured supply of raw cashews to Vietnam. Cote d'Ivoire is largely replicating its successful model of cocoa in cashew. These are just two examples. The gist is every major raw cashew producer is evolving its own model to add value to raw cashew and in the process generate employment and wealth for the nation. Organisations such as ACA and ACi along with its partners are enabling and hastening this transition. Africa, undoubtedly is the most happening place for cashew and rightfully, this decade belongs to African cashew industry

Cashew Processing in Africa

Africa produces 42 % of the world's cashew. The processing of cashew nuts has a long history on the African continent. Mozambique was the first country in Africa to process cashew nuts on an industrial scale. In the 1960s, Mozambique was the world's largest producer of cashew nuts, accounting for an average annual share of 35 per cent of global production. In parallel, a local cashew-processing industry emerged. More recently, the cashew-processing industry in Mozambique has begun to re-emerge and, in 2018, ranked second in capacity and output in Africa (table A).

Table A: Processing capacity and utilization:

Selected cashew-growing countries	Estimated processing capacity, 2018 (tons)	Processed, 2018 (tons)	Utilization rate (percentage)
India	2000000	1675000	83.8
Viet Nam	1800000	1450000	80.6
Côte d'Ivoire	140100	68000	48.5
Mozambique	105700	53517	50.6
United Republic of Tanzania	42073	10000	23.8
Ghana	45750	23300	50.9
Nigeria	48000	20000	41.7
Benin	35000	18750	53.6
Burkina Faso	18000	8701	48.3

Source: UNCTAD calculations, based on data from Com Cashew, DCCD and United Republic of Tanzania, 2020.

Côte d'Ivoire is the country with the largest cashew processing industry on the African continent, with a capacity of 70,000 tons per year. Other countries in Africa with significant cashew-processing industries include Benin, Burkina Faso, Ghana, Mozambique, Nigeria and the United Republic of Tanzania. However, the capacity of these countries is still much lower than their respective production of RCN. The opposite is the case in India and Viet Nam, which have the largest processing capacities in the world. In both countries, the domestic processing capacity is far larger than cashew nut production, which gives rise to their strong import demand for RCN in international markets. A common feature of the processing industries in Africa is the high level of disparity between capacity and utilization. Among the main cashew-processing countries in Africa featured in table A, the average ratio of capacity to utilization was less than 50 per cent in 2018, which indicates that they face difficulties in securing a stable and sufficient supply of raw materials to keep their operations going throughout the year. This suggests that policies aimed at increasing cashew processing in Africa need to focus not only on adding new processing sites but also on increasing the utilization rates of existing units. Another way of highlighting the potential for value addition that is foregone if cashew nuts are exported as RCN is to consider the prices paid at different stages of the value chain.

Future trade strategy

The global cashew market is characterized by fragmentation and long supply chains. While more than 50 per cent of global cashew nut production takes place in Africa, more than 85 per cent of shelling industries are located in Asia and more than 60 per cent of cashew kernel exports are destined to the United States and the

European Union. Cashew-growing countries that mainly export RCN rather than processing them at scale forego significant potential for value creation and employment generation. The addition of value to cashew byproducts such as shells and apples represents a significant underutilized potential in many cashew growing countries. Since production typically takes place on smallholdings in rural areas, there is a direct link between value addition in the cashew sector and the achievement of poverty reduction and other Sustainable Development Goals. This untapped potential is greatest on the African continent, where, in 2018, less than 15 per cent of harvested RCN were processed and the bulk of cashew by-products was discarded as waste. Current market trends and developments in the main cashew consumer markets offer opportunities for existing cashew processors and potential investors in the sector. The global demand for cashew kernels is on a sustained growth path, which creates opportunities for new market entrants. In addition, the traceability, transparency and sustainability of food supply chains is becoming increasingly important for consumers and suppliers, which could benefit processors in Africa that source RCN locally rather than through long supply chains and from multiple sources. For instance, the Sustainable Nut Initiative aims to increase the transparency and sustainability of nut supply chains. Furthermore, the growth of the organic food sector creates opportunities to develop certified organic cashew products that can be marketed at premium prices. For instance, in 2009–2018, retail sales of organic products in the European Union grew by 121 per cent. For such opportunities to materialize, the entire cashew value chain needs to be strengthened in cashew growing countries that aspire to develop and expand cashew-processing industries. Therefore, strategies and policy interventions in the cashew sector need to be based on clear objectives and take a holistic view that includes production, processing and trade. A stable supply of high-quality RCN is the backbone of every cashew industry. Therefore, the agricultural policy framework needs to be supportive of practices and investments that increase the productivity and output quality of cashew orchards. In addition to a reliable supply of RCN, cashew processors need a policy environment that enables them to operate with competitive transformation costs and facilitates access to the main export markets for cashew kernels. Promoting the development of cashew byproducts such as CNSL, briquettes from de-oiled cashew shells and products based on the cashew apple can further strengthen value and job creation in the cashew sector. Finally, regional cooperation and trade facilitation, in particular in Africa, can contribute to market stability and help to reduce supply-side risks for processors

Vietnam Cashew Industry: A Quick view

Raw Cashew Nuts Sector: Cashew is grown in 300,000 ha in Vietnam with an average productivity of 1000 kg/ha. Moving plantations from mountains, better seed programme, choosing proper seasons for

seeding and harvesting and use of Integrated Pest Management (IPM), Vietnam aims to increase productivity to 1700 – 2000 kg/ha. Vietnam has a challenge of not being able to allocate more land to cashew. Thus, productivity improvement is the option.

Raw cashew Nuts import (Metric Tonnes)

2017	1291726
2018	1211720
2019 (till Sept)	1288121

Cashew Kernel Market:

Vietnam cashew industry in 1980s was similar to the cashew industry in Africa today. Processing started in 1990. In three decades, Vietnam has raised itself into becoming the second largest processor of Raw Cashew and the largest exporter of cashew kernel (for the 8th consecutive year since 2006).

Cashew Kernel export (Metric Tonnes)

2017	355939
2018	379774
2019 (till Sept)	325121

Resource person's Personal interventions/participation-Experience sharing

Commercial Cashew Plantation – Madagascar (Africa)

Was involved with agency Verama at Madagascar with a consultancy task of one of the largest Cashew plantations in Madagascar (Africa) which has its cashew plantation established in about 500 Hectares. We assessed their growth & yield potential of existing Cashew plantation, exploring avenues for boosting its yield levels by way of adoption of new/improvised/latest intercultural practices focusing mainly on its training /pruning/replanting or any other scientific approach. We also explored the possibilities for new planting of Cashew under area expansion approach to enable the company to produce nuts to the requisite volume to make it a globally competitive unit.

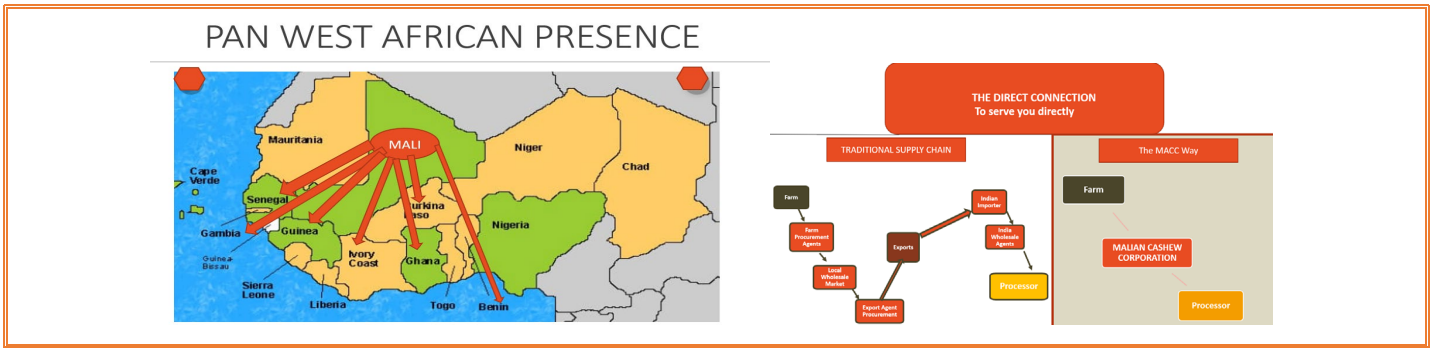
Top working:

It was proposed to have immediate action plan for taking up top working in the area which was already planted at the VERAMA plantation at present Existing commercial area that is a poor yielder was also be brought under this plan. Top working was being carried out to the extent of 135 hectares which is to the extent of 30% of the total plantation programme (450 Hectares)

The Top working activity is for a period of 3 years with 30 Hectares, 45 Hectares and 60 Hectares to be top worked during the 1st, 2nd and 3rd years respectively. The Top working will have a good mix of the proposed varieties in the percentage of 20% of each variety out of the 5 varieties recommended.

Mali-Bamako

A brief stint at Mali with Malian Cashew Corporation (MACC)for understanding their trade and business practices and to forge a business plan ahead was carried out. The MACC has its presence in 7 countries across west Africa exclusively dealing with export of raw cashew nut (RCN) and other agri-forest produce and products from their network countries in the region.



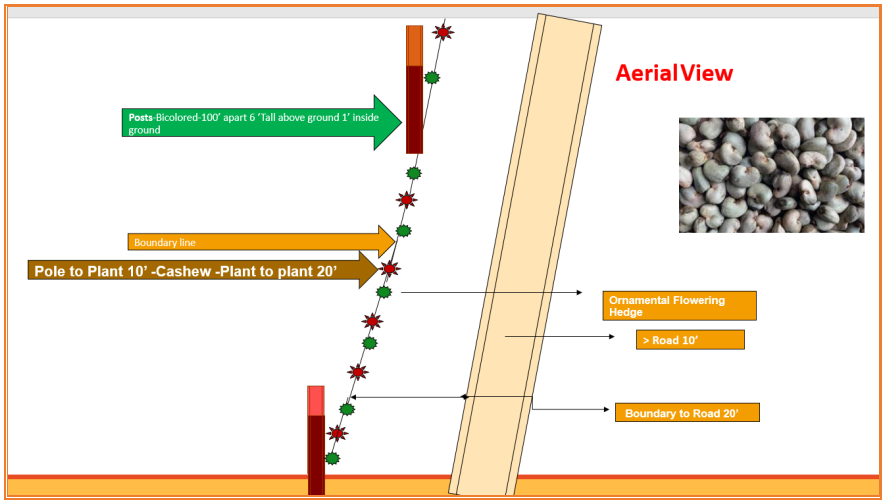
A collaborative workshop was organised by Karnataka Cashew Development Corporation (KCDC) Mangalore in Cashew titled “Recent developments in cashew processing and raw nut handling by growers and traders” on 16th October 2019 at BIRD (NABARD Training Campus-Bondel) in Mangalore. GOI, Directorate of Cashew and Cocoa Development (DCCD), Kochi, Directorate of Cashew Research (DCR), Puttur, Industrialists, Professionals, Entrepreneurs, Scientists, Agri-business, MACC-Bamako and farmers in the field of Cashew and others participated in the aforesaid workshop.

The objective of the workshop is to discuss the emerging trends related to Cashew processing, so as to upgrade with the recent or advanced technologies and look forward to improved packaging and also for forging a firm bond between growers and traders involved in raw cashew nut trade.

Integrated Agriculture Complex in Guinea Republic (Conakry)-West Africa

A high profile multi-sectoral Agri-development project was conceived, prepared and commenced in November 2019 for Development of 1700 hectares of existing fallow, partly cultivated, even terrain land into an “Integrated multi-crop and multi-activity complex with crop husbandry, processing, trade, market, farm advise and related services” involving an investment of 160.014 million AED. The site is located 100 Km away from the city of Conakry of Guinea Republic.

The entire boundary of the proposed integrated crop complex was having Cashew plants planted as border planting concept which when calculated (Total No of plants) was roughly was of 400 hectares.



Cashew in India

Cashew (Anacardium occidentale L.) is an important tropical perennial tree crop, originally grown in coastal areas, but now extending also far inland. Cashew is known by many names. In Mozambique, the Maconde tribe refer to it as the "Devil's Nut". It is offered at wedding ceremonies as a token of fertility and is considered by many to have aphrodisiac properties. The cashew tree, native to Brazil, was introduced to Mozambique and then India in the sixteenth century by the Portuguese, as a means of controlling coastal erosion. It was spread within these countries with the aid of elephants that ate the bright cashew fruit along with the attached nut. The nut was too hard to digest and was later expelled with the droppings. It was not until the nineteenth century that plantations were developed and the tree then spread to a number of other countries in Africa, Asia and Latin America. Cashew processing, using manual techniques, was started in India in the first half of the twentieth century. It was exported from there to the wealthy western markets, particularly the United States. It is a major export crop in terms of foreign exchange earnings in countries like Brazil, Vietnam, India, Nigeria, Tanzania, Indonesia, Guinea-Bissau, Cote D'Ivoire, Mozambique and Benin. Cashew nuts are common appetizers, like peanuts and pistachio nuts. They are also used in the food industry, and as an ingredient in various confectionery products. The cashew nut kernels have good nutritional values to human beings. Due to its high nutritional value, even small and broken pieces of cashew nut kernels find a market in confectionery products. Almost all varieties of A. occidentale produce sweet juicy apples, with high soluble sugar (fructose and sucrose) content, which are consumed as fresh fruits; or used to make various apples products, such as juice and wine.

During 60's, India, Mozambique, Tanzania, Brazil and Cote d'Ivoire were the only producers of RCN. Till mid of 70's, the same trend continued with some new entrants in the market. In 70's, Indonesia and in 80's Vietnam became one among the new entrants of RCN in the world.

India is the largest producer of raw cashew nut in the world with 1.01 million ha area under cultivation and 0.75 million tons production in 2013. The area under RCN has been increasing consistently year-aft er-year. From 1961, cashew cultivation

Over the past years cashew nut production in India has been increasing steadily with the release of new high yielding graft s and adoption of good agronomical practices. Recently many farmers in India started to adopt High Density Planting (HDP) which accommodates 625 plants in a hectare which definitely reflects on production in near future.

Kerala, Goa and Karnataka states are the traditional RCN producers and processors for a long ti me in India. Later the RCN cultivation expanded towards other states like Maharashtra, Andhra Pradesh, Odisha and Tamil Nadu. Commencement of National Horti culture Mission (NHM) Schemes in India during 2005-06 has become a boon for development of cashew sector. There are about 100 regional cashew nurseries under public and private sector catering to the needs of graft requirement in addition to large number of small to medium cashew nurseries. At present, RCN production is gaining momentum across the country. From being south centric, RCN production and processing is now expanding to the central India and is further expected to expand to the other parts of the country. The recent non-traditional entrants into RCN production include Assam, West Bengal, Tripura, Gujarat, Jharkhand, Andaman Nicobar, Chhattisgarh, etc.

CASHEW –INDIA

Year wise area, production and yield of cashew in India

States	Area ('000 ha)	Production ('000 MT)
Maharashtra	186.2(18)	256.61(32.4)
Andhra Pradesh	185.57(18)	111.39(14)
Orissa	182.91(17.6)	93.5(11.8)
Karnataka	126.71(12.6)	85.15(10.9)
Kerala	87.29(8.30)	83.98(10.7)
Other States	266.81(25.5)	148.71(20.2)
Total(India)	**1035.49**	**779.34**

Source: Horticulture at a glance, 2017. Figures in parenthesis represent %

Cashew Processing in India

Cashew processing, using manual techniques, was started in India in the first half of the twentieth century. It was exported from there to the wealthy western markets, particularly the United States. It is a major export crop in terms of foreign exchange earnings in countries like Brazil, Vietnam, India, Nigeria, Tanzania, Indonesia, Guinea-Bissau, Cote D'Ivoire, Mozambique and Benin. Cashew nuts are common appetizers, like peanuts and pistachio nuts. They are also used in the food industry, and as an ingredient in various confectionery products.

Cashew processing is a very competitive but also a potentially lucrative activity that can and should be exploited by more small-scale processors. There are several good reasons why small-scale producers and processors should get involved in cashew processing, including the following:

- Cashew kernels are a high value luxury commodity with sales growing steadily at an annual rate of seven percent, with every expectation that the market will remain strong.

- There is substantial potential to exploit cashew by-products, such as cashew butter, from broken nuts, CNSL for industrial and medicinal purposes and the juice of the cashew apple that can be processed further.

- Cashew is a good crop for smallholder farmers. It requires few inputs and harvesting does not coincide with peak labour demands for other food crops.

Thus, cashew has the potential to increase the incomes of poor producers, to create employment opportunities during harvesting and processing and to increase exports. However, as with all small-scale processing operations, cashew processing is not without risk or problems. In order for the small-scale processor to succeed, there are certain constraints, which also need to be addressed from time to time.

- Cashew production is very weather dependent so supply is variable.
- World prices, although stable on average, are Highly volatile in the short term.
- Luxury goods must be of high quality in order to compete directly in the world market, have to maintain a high level of standards,
- Branding and marketing are required.
- Exploitation of by-products requires new technology, which may be expensive or difficult to obtain.

Export of Cashew Kernel, CNSL and Import of Raw Cashew nut in India

Year	Cashew Kernel Export from India		CNSL Export from India		RCN import into India	
	Quantity (MT)	Value (Rs. Cr.)	Quantity (MT)	Value (Rs. Cr.)	Quantity (MT)	Value (Rs. Cr.)
2019-20	67,647	3867.165	4,605	23.09	9,38,038	8,861.58
2018-19	66,693	4,433.99	5,300	26.85	8,35,463	10,929.00
2017-18	84,353	5,870.97	8,325	32.63	6,49,050	8,850.03
2016-17	82,302	5,168.78	11,422	44.00	7,70,446	8,839.42
2015-16	96,346	4,952.12	11,677	57.59	9,58,339	8561.01

Courtesy: DCCD

Discussions, Views, Trends, Points to Ponder and Future Forward

Comparisons between major cashew countries

India

- ✓ We now are better placed as INDIA is now one of the largest consumers of cashew
- ✓ Domestic production of RCN -50%-Scope for expansion
- ✓ Potential land pockets are available hence expansion of area possible

VIETNAM

- ✓ Low domestic consumption
- ✓ Fully dependent on exports (90%)
- ✓ Domestic RCN production-Limited scope for expansion as potential land pockets are absent
- ✓ Rely heavily on Africa for RCN supply

AFRICA

- ✓ Economy weak coupled with poor governance
- ✓ Plenty of land for production expansion-High growth potential

- ✓ Processing sector still at nascent stage
- ✓ Low domestic consumption of kernels
- ✓ Depend primarily on export of RCN

Cashew in India-Past and present

Before: Till the year 1975

- India Global leaders in cashew
- 85% of Exports
- 90% of the Processing
- 60% of the Global production

Present

- Today-India exports 10% of the world trade in Cashew Kernels
- 35% of processing (Continues as one of the largest processors)
- 18.68% of Global production of RCN is from India
- India now is one of the largest consumers of cashew kernel
- Vietnam has since displaced India as a leader in Cashew Global scenario
- Involves large number of small and marginal farmers- About 70%
- Nearly 2.00 lakh workers, more than 90% of whom are women, are directly employed
- Nearly two million people- involved, directly and indirectly

Points to Ponder

Cashew-Crop & Segment

- Cashew quality- One of the best in the world
- Cashew is recently introduced crop in India- Only 4 centuries old
- Initially Cashew crop was taken up as a waste land-commercial crop
- If one considers past average per unit area production, the present situation/trend is very encouraging
- Sales- well balanced, export Versus Domestic
- Fewer stages before export in most of the African countries

Cashew Processing sector

- Financing institute friendly
- Compact block
- Good potential for future expansion
- Sun rise industry- better profit margins
- Organised work force
- Productivity ranges up to 85-95%
- Indian cashew skill like Brazilian slum hand embroidery
- 70% of process innovations originated from here
- Entrepreneurship spirit continues to be very high
- Relatively Lesser non-productive investments
- Working approach-structured
- Accountability of products
- Diversified products
- High value & quick realization - Efficient conversions
- Minimum wastage/residue
- Minimum pollution related issues
- Scope for Future expansion of unit

Risks

- Large scale project- Higher responsibility
- Out and out industry- Stringent norms
- Total outsourcing concept/ dependent
- Electricity high consumption- can affect viability
- More tilt towards infrastructure and other services
- High investment per unit area
- High liability

Future Forward

Cashew – INDIA

Area	10.35 lakh Ha
Production	7.79 lakh tonnes
Productivity	850–885 Kg/ha
Present requirement from processors	15 – 16 lakh tonnes
Requirement by 2030	30 – 40 lakh tonnes

			RCN –INR Per kg		
Year	Kerala	Karnataka	Andhra Pradesh	Tamil Nadu	Goa
2019	120.00	135.00	84.00	110.00	130.00
2018	158.87	148.00	144.00	150.00	164.00
2017	133.03	137.22	114.18	101.8	142.02

Courtesy: DCCD

EXPORT

- India exports mostly bulk packs of cashew nuts, hence boost needed for export of value-added products
- Address presence of chlorophenol in Indian cashew

IMPORT

- Being Agri commodity- Reduction in GST on imported RCN
- Grading at port of dispatch before import of RCN -Mandatory

EXPANSION

- One India one cashew model
- Golden Cashew Neck lace-Gujarat to West Bengal
- Combination of Co win Portal model & Fastag -incentive (2 prong) for Cashew expansion
- Aggressive & time bound thrust/focus on Cashew New Planting/Existing Planting/Replanting/Top working

CORPORATIONS

- KCDC -ha: 25,655 & OSCDC -ha: 27878-Good existing potential base-Excellent scope for crop production potential tapping

DOMESTIC

- ✓ Backward integration-traceability-Future ready
- ✓ Farmer hand holding needed in post-harvest aspects
- ✓ Calls for establishment of an exclusive world class farmer run platform for cashew -cashew exchange

References: GIZ, FAO, UNCTAD, DCCD, Cashe

Application of Contemporary ICTs for Transfer of Technology in Cashew and extension strategies for promoting Cashew

Aswathy Chandrakumar

ICAR-Directorate of Cashew Research, Puttur

Introduction

Cashew (*Anacardium occidentale*) is a native of Eastern Brazil. It was introduced to India along the west coast by the Portuguese during the 16th century to control soil erosion. However, India became the hub for processing raw cashew nuts and bulk of the cashew kernel requirement of the global market was met by our country. The availability of cheap manual labour in India when compared to many African countries helped India to offer kernels at competitive prices in the world market during 1950s. Cashew has attained the status of commercial plantation, providing gainful employment to more than one million people especially women in India. As on 2018-19, Cashew is cultivated in an area of 11.05 lakh ha, producing 7.43 lakh tonnes raw cashew nuts in India. At global level, production more than doubled during the period from 2000-2018 as a result of increased demand for cashew kernels. Keeping in view of the significance of the crop to India, the present chapter discusses about the existing extension strategies for promoting the crop and leveraging the potential of ICTs for increasing the production and protection of crop.

India has a long history of cashew processing and trading as early as 1920s. Efforts were made to formulate targeted policies and establish dedicated agencies for the promotion of the crop. Today we have the Directorate of Cashew and Cocoa Development in Kochi, Kerala as the nodal agency for promoting all developmental activities related to Cashew while ICAR-Directorate of Cashew Research, a research institute under the Indian Council of Agricultural Research caters the research needs of the country. Being a nodal agency for promotion of the crop, DCCD has different schemes which is tabulated below-

Table 1: Schemes promoted by DCCD to give financial assistance for cultivation of cashew

Sl. No.	Name of the Scheme	Particulars
1.	Establishment of New Plantations of Cashew (3 years)	Financial assistance @ Rs.20, 000/- per ha for meeting the expenditure on planting materials and cost of materials for INM/IPM in three installments in 60:20:20 subject to survival rate of 75% in 2nd year and 90% in 3rd year without integration with drip system.
2.	Cashew productivity improvement programme through High Density Planting (5m x 5m spacing) (3 years)	Financial assistance @ Rs.40, 000 per ha for meeting the expenditure on planting materials and cost of materials for INM/IPM in three instalments in 60:20:20 subject to survival rate of 75% in 2nd year and 90% in 3rd year without integration with drip system.
3.	Establishment new plantations by replacement of senile plantations and replanting with high yielding varieties (3 years for Forest department and Corporations)	The pattern of assistance will be as per NHM guidelines i.e. 40% of the cost subject to Rs.20000/- per ha in three instalments of 60:20:20 subject to the survival rate of 75% in second year and 90% in third year.
4.	Establishment and Modernisation of Cashew Nurseries (1 year)	For setting up big nursery maximum of 20.00 lakhs per units as project based activity. For small nursery maximum of 7.50 lakhs per units as project based activity. For modernization/upgradation of existing cashew nursery, Rs.5.00 lakhs

(Source: DCCD website)

Issues and Challenges in Cashew sector

Despite the various developmental efforts initiated at the global and regional levels, several issues and constraints are faced in the sector which are enlisted below-

- Low price for the cashew nuts
- The "Low maintenance crop" myth that persists
- There is no rejuvenation of senile cashew orchard that takes place, which leads to some cashew plants dying.
- Plant protection measures against Tea Mosquito Bug (*Helopeltis Antonii*) and Cashew stem and root borer have not been initiated.
- There is a wide knowledge gap among cashew growers on the canopy management issues which effects their productivity.
- Cashew apple is underutilised

- ❑ Lack of organized value chain in Cashew
- ❑ High cost of processing
- ❑ Improper drying of nuts at farmers' field causing more delay and burden for the processors.
- ❑ Competition from other countries like Vietnam where mechanization is more

Leveraging the potential of ICTs for promoting Cashew

Information and Communication Technologies (ICTs) play a key role in information dissemination and have important implications in the field of agriculture. Some of the ICT interventions implemented from ICAR-Directorate of Cashew Research, Puttur includes-

1. Cashew India App

This android based app gives comprehensive information on cashew cultivation aspects and market aspects which will be beneficial for all the stakeholders in Cashew. This app is available on google playstore. It is available in 11 languages and currently 3262 people have downloaded this app. There is facility to book grafts through this app and presently 20005 grafts have been booked through this.

2. Cashew Pest Database

This database is available on ICAR-DCR website providing complete information with photographs regarding the important pests of cashew, minor pests, pest calendar and the symptoms and damages caused by each of these pests.

3. Cashew Nutrient Manager

This mobile based app available in google play store and helps the users to calculate the fertilizer doses based on the soil conditions and general recommendations of nutrients can also be taken from this app. The app also provides information on liming application and foliar application.

4. Cashew Community whatsapp group

This whatsapp group managed by ICAR-DCR provides an online platform to voice the opinions of all the stakeholders like cashew farmers, cashew processors, scientists and policy makers. Presently, 203 participants from various states are members of this group. The whatsapp group is very active in terms of discussion on various aspects of cashew cultivation.

References:

https://cashew.icar.gov.in/

https://www.dccd.gov.in/