



# CASHEW

Improvement, Production  
and Processing

P.L. Saroj



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*Improvement, Production  
and Processing*

## The Editor

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# CASHEW

## *Improvement, Production and Processing*

— Editor —

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2017

**Daya Publishing House<sup>®</sup>**

*A Division of*

**Astral International Pvt. Ltd.**

**New Delhi – 110 002**

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*Publisher's Note:*

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**Cataloging in Publication Data--DK**

Courtesy: D.K. Agencies (P) Ltd. <docinfo@dkagencies.com>

**Cashew** : improvement, production and processing / editor,  
Prof. P.L. Saroj.

pages cm

Contributed articles.

Includes index.

ISBN 978-93-5124-825-5 (Hardbound)

ISBN 978-93-86071-55-2 (International Edition)

1. Cashew--India. I. Saroj, P. L., editor.

SB401.C3C37 2017 DDC 634.5730954 23

*Published by* : **Daya Publishing House®**  
*A Division of*  
**Astral International Pvt. Ltd.**  
– ISO 9001:2008 Certified Company –  
4760-61/23, Ansari Road, Darya Ganj  
New Delhi-110 002  
Ph. 011-43549197, 23278134  
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Website: www.astralint.com

*Digitally Printed at* : **Replika Press Pvt. Ltd.**

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### **FOREWORD**

With sustained research and development efforts by different research organizations in the country, cashew (*Anacardium occidentale* L.) has emerged as one of the most important export oriented horticulture crop in India. At present, India is major player in cashew trade and earning a substantial amount of foreign exchange by export of cashew kernel and cashew nut shell liquid. Besides, cashew processing industries in India is generating job opportunities especially to the womenfolk. However, productivity of cashew in the country has remained stagnant though the area and production have been increasing since last several years.

Research and development programmes at ICAR-Directorate of Cashew Research at Puttur and also at different Centres of All India Coordinated Research Project on Cashew under State Agricultural Universities have resulted in the development of a number of high yielding varieties and location specific production technologies. These technologies need to be transferred and adopted at farmers' field to break yield stagnation.

I feel happy to find that valuable information on technology and other aspects of cashew nut has been compiled by the ICAR-Directorate of Cashew Research in the form of a book titled "Advances in Cashew Research". The work done in the area of germplasm conservation, crop improvement, crop management, crop protection and post harvest technology done so far has also been included in this publication. I am hopeful the book will serve as useful guide in formulating future research and development strategies for improving production and productivity of cashew in the country beside providing reference material to the researchers, teachers, students, and extension workers. I take this opportunity to congratulate Dr. P. L. Saroj, Director, ICAR-Directorate of Cashew Research, Puttur for his efforts in compiling and presenting valuable information on cashew in one place in the form of book.

**[Ramesh Chand]**



# Preface

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Cashew (*Anacardium occidentale* L.) is a precious gift of nature to the mankind. Cashew is produced commercially in as many as 32 countries in the tropical regions of Asia, Africa and Latin America. Asiatic zone comprising of India, Indonesia, Philippines, Sri Lanka, Thailand, Vietnam and Malaysia accounts for major global production of cashew nut. In India, cashew was introduced by Portuguese travelers in 16<sup>th</sup> century for afforestation of degraded lands in coastal region but now cashew has moved from forest confine to commercial horticulture crop. At present, cashew is grown in an area of about 10.27 lakh ha with a production of 7.25 lakh tonnes of raw cashew nuts and a productivity of 706 kg/ha (2014-15). Though, India is largest producer, processor, exporter and consumer of cashew in the world and earning foreign exchange of Rs. 5488.66 crores per annum (2014-15) by the export of cashew kernel and cashew nut shell liquid but still India is far behind in cashewnut productivity than potential productivity. This necessitates reorienting our research and development strategies in order to address the growing demand of raw cashewnut by the processing industries.

After establishment of ICAR-Directorate of Cashew Research, Puttur, Karnataka (Formerly National Research Centre of Cashew) in 1986 and also separate All India Coordinated Research Project on Cashew; large number of varieties and production as well as processing technologies have been developed for adoption of end users. Therefore, it was thought to have stock of research and development information available in the country in form of a book "*Cashew: Improvement, Production and Processing*" which will serve as bench mark to decide way forward in cashew sector.



I hope that the publication will serve as a valuable reference to the academicians, policy planners, development departments and extension workers engaged in cashew research and development in the country.

I take this opportunity to express our sincere gratitude to Dr. N. K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR, New Delhi for his guidance to bring out this publication. I am grateful to former Directors of ICAR-Directorate of Cashew Research, Puttur; all ICAR-DCR staff and all those who are involved in R and D of cashew in the country including farmers. The support of my wife Smt. Neelam Saroj and Mr. O.G. Varghese, Private Secretary to the Director, ICAR-DCR in bringing out this publication is also acknowledged.

*Prof. P.L. Saroj*

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# Minor Pests and their Management

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and D. Sundararaju*

## 1. Introduction

Cashew is an important commercial edible plant grown in India. Globally, more than 300 species of arthropods are associated as pests of cashew (Vanitha and Saroj, 2015). Among them, certain pests affect the cashew plant only temporarily, while others live for several generations on the plant. In some instances, the attack may result even death of the plant, but in most cases damage results in yield reduction. All parts of the plant *viz.*, leaf, stem, bark, root, flower, apple and nut are infested by one or other pest species, resulting in yield loss. A yield loss of 50 per cent was reported annually due to pests and diseases in cashew (Hari Babu *et al.*, 1983). Apart from two important major pests *viz.*, tea mosquito bug and cashew stem and root borer, there are few insect pests which cause economic damage in certain occasions.

Depending on the climate, location, age and management measures of the plantation, each geographic region has its own distinctive pest complex. Documentation of pest diversity across different cashew growing regions is necessary to formulate effective management strategies. Though, each geographical region has its own distinctive pest fauna composed mainly of indigenous species, a small number of key pests are found common throughout the world *viz.*, tea mosquito bug (*Helopeltis* spp.), cashew stem and root borer (*Plocaederus* spp.), leaf miner (*Acrocercops* spp.) and thrips (*Selenothrips rubrocinctus* Giard). Damage by different insect species, at different intensities, is generally widespread throughout all cashew growing countries. Many insect pests have the ability to move long

distances and could become a pest at a new place in future. In addition, as the area of cashew expands, pest dynamics also change. In India alone, more than 190 pests are reported on cashew in different cashew growing states including Andaman and Nicobar. This chapter deals with the advances made in understanding of minor pests of cashew, their biology, ecology and management.

## 2. Biology, Ecology and Management

Among different cashew pests, some may not be problematic in certain regions but could be a problem in other regions. In general, management actions taken for TMB could manage these pests also, but separate spraying may be required during certain periods to prevent economic loss. The details of important minor insect pests of cashew are given below. Management measures suggested are based on several reports and results of trials conducted at AICRP on Cashew Centres.

### a. Shoot Tip Caterpillars

#### ***Anarsia epotias* M. and *Hypotima haligramma* M. (Lepidoptera: Gelechiidae)**

Caterpillars of *A. epotias* and *H. haligramma* damage the shoot tips of cashew during post monsoon flushing period. Larvae of *A. epotias* are pale yellowish green with black head and turn pinkish-brown later. While, larvae of *H. haligramma* are tiny, yellowish to greenish brown in colour. The pest is presently distributed in Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Odisha. This pest is regularly reported in the east coast tracts of India (Mohapatra *et al.*, 1998; Jena *et al.*, 1985). The egg, larval and pupal period of *H. haligramma* last for 3-4 days, 12-16 days and 7-10 days respectively, and the life cycle is completed within 25-29 days. Pupation takes place inside the bore holes on the shoots or inflorescences. While moths of *A. epotias* lay upto 60 eggs/female either singly or in groups of 10-20. The egg period lasts for 3-4 days and the larva feeds inside the tunnel. Pupation takes place in larval tunnels of the attacked shoot, in crevices of the branches, twigs or at the cut end of branches. Pupal period is 7-10 days and the total life cycle is completed within 27-29 days (Remamony, 1965).

During active growth period, caterpillars of *A. epotias* at the early stage web together the tender leaves and feed within. Later on, they bore in to the terminal shoots and tunnel inside up to 2-3 cm. A gummy substance oozes out from the infected tips and finally the attacked shoots dry up. Larvae of *H. haligramma* also damage shoot tips by folding the fresh leaves and feed within and can tunnel upto 2 cm. The larvae may also damage inflorescences subsequently. Exudation of gummy web like substances mixed with faecal pellets from the injury site can be noticed. Later, the terminal shoots turn black and perish, which results in production of auxiliary shoots.

In west coast, up to 13.0 per cent damage in newly emerging post-monsoon flushes (in October) and 10.5 per cent in pre--monsoon flushes (in May) have been reported (Pillai *et al.*, 1976) indicating the significance of this pest. Abiotic factors do not exert a significant influence on infestation and population of this particular pest (Mohapatra *et al.*, 1998).

## Management Measures

Spraying may not be required, since natural enemies including parasitoids take care of this pest. Four larval parasitoids, *viz.*, *Pristomerus* sp. (Ichneumonidae), *Apanteles* sp. (Braconidae), *Elasmus* sp. (Elasmidae) and *Sympiesis* sp. (Eulophidae) have been recorded on shoot tip caterpillar larvae causing parasitism up to 25 per cent. But, under severe incidence, spraying of either quinolphos (2 ml/lit) or phosalone (2 ml/lit) or phosphamidon (2 ml/lit) or monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) or profenophos (1.5 ml/lit) can manage this pest effectively.

### b. Leaf Miner

#### ***Acrocercops syngamma* M. (Lepidoptera: Gracillaridae)**

Leaf miner is one of the serious pests of cashew during post monsoon period throughout the country. Its occurrence was recorded in Goa, Karnataka (Sundararaju, 1984, Sundararaju and Bakthavatsalam, 1994), Odisha (Jena and Satapathy, 1988) and also Andaman Islands (Jacob and Belvadi, 1990). Eggs are tiny, transparent and glue like, laid on the upper side of tender leaves. Eggs hatch in 5-7 days. During the developmental period, larvae are dull white in colour. Full grown caterpillars measure about 5-7 mm in length, are reddish brown in colour. After full development, the larvae fall off to the soil for pupation emerge as adults after 7-9 days (Pillai *et al.*, 1976). The adult is a tiny silvery grey moth with red eyes.

The incidence is most common in post monsoon flushes during August-December reaching the peak during October- November, but incidence can be seen upto April at low level. The mining injury by caterpillars occurs both on tender leaves as well as shoots. Young plants are observed to be prone to attack by this pest. The caterpillars mine and feed below the epidermal layer of the tender leaves and shoots causing extensive blisters, which later dry up resulting in distortion, browning and curling of the leaves. As the attacked leaf, holes develop due to drying out of the damaged matures portion. Generally, 1-5 larvae are seen in a single leaf (Rai, 1984; Jena, 1985), but up to 45 larvae have been observed during peak infestation at Puttur, Karnataka (Vanitha *et al.*, 2015). Abraham (1959) estimated around 26 per cent leaf miner damage in severely infested cashe leaves. Varied leaf damage levels were recorded in different states *viz.*, Kerala (70-80 per cent), Karnataka (60 per cent), Andhra Pradesh (6-20 per cent), Odisha (8.4 per cent) and West Bengal (18-20 per cent) respectively (Basu Choudhuri, 1962; Rai, 1984; Ayyana *et al.*, 1985; Jena *et al.*, 1985; Chatterjee, 1989). The leaf miner pest status was assessed on medium aged common cashew varieties at Puttur during 2011-2014 and found low to medium (Vanitha *et al.*, 2015).

## Management Measures

Two larval parasitoids *viz.*, *Chelonus* sp. (Braconidae) and *Sympiesis* sp. (Eulophidae) have been recorded on leaf miners in Kerala and Goa. Recently, three larval parasitoids namely, *Chyrsocharis* sp., *Aprostocetus* sp. and *Closterocerus* sp. (Eulophidae) were recorded in Puttur region of Karnataka. Spraying may not be required since these larval parasitoids manage this pest even up to 50 per cent. But

under severe incidence in nursery and young plants, spraying is required. Spraying of quinolphos (1.5 ml/lit) or monocrotophos (1.5 ml/lit) or profenophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) can effectively manage leaf miners.

### c. Leaf Folder and Leaf Rollers

***Hypatima haligramma* M. (Gelechiidae), *Caloptilia tiselaea* M. (Gracillariidae), *Dudua aprobola* M. (Tortricidae), *Sylepta derogatta* F. and *S. auranticollis* (Pyralidae)**

Larva of *H. haligramma* is yellowish green with black head and prothoracic shield, pupates inside leaf roll, pupa is small and brown. Adult is a small, narrow shiny moth, with forewings having two whitish transverse bands. While, larva of *C. tiselaea* is sluggish, light yellowish with creamy head, grows up to 7 mm and pupates inside a silken cocoon by making a small folding on lamina. Adult is a tiny, narrow plume moth, dirty white in colour. But, larva of *D. aprobola* looks dark green, very active with black head and prothoracic shield, grows upto 1.5 cm long, pupates inside leaf roll while, adult is a tiny narrow grey moth. Wings are smoky green with ornamentation having black spot towards apical margin. Whereas, larva of *S. derogatta* looks glistening green with dark brown head and prothorax, grows up to 2.5 cm and pupates inside the leaf roll. Adult is a small moth with light yellowish wings having brown wavy margins. In Kerala, pink leaf roller, *Anigraea albomaculata* (Noctuidae: Lepidoptera) occurs on cashew (Pathummal beevi *et al.*, 1993). Incidence of leaf folder and leaf roller has been reported on cashew in Kerala, Karnataka, Andhra Pradesh and Odisha.

These pests cause considerable damage to post-monsoon tender foliage of cashew between August and January. The incidence of *C. tiselaea* commences during the first fortnight of November and prevails up to the end of January and peak population is seen during the second fortnight of December. Higher leaf infestation was recorded in early cashew types compared to mid and late cashew types (Mohapatra, 2007). At Andhra Pradesh, *D. aprobola* and *C. tiselea* occur from second fortnight of August to first fortnight of March and maximum population is seen during November. Higher population and damage were observed in the plantation of 8-11 years' age (Ayyana and Ramadevi, 1987).

In general, early cashew types record higher infestation by leaf folders compared to late cashew types. Larva of *H. haligramma* rolls up the leaf margin towards ventral side. Roll is narrow, tight and the larva feeds the leaf margins, as a result portions of the leaf dry up. Similar kind of roll but big sized is made also by *D. aprobola*. Larva of *C. tiselaea* folds loosely the leaf either from the top or from lateral margin towards the midrib ventrally. The larva remains inside the roll and feeds from inside by scraping the green portion of the leaf lamina which later dries up. Larva of *A. albomaculata* damages tender leaves by making spindle shaped folds. Two to four terminal leaves are folded longitudinally one above the other and fastened with silken threads to form a tight tubular roll at the growing point thus delays emergence of inflorescence. Larvae of *S. auranticollis* during their early stages roll the tender leaves and scrape the green matter, but later defoliate entire

leaves. Whereas, a one more leaf webber namely, *Macalla albifusa* (Pyralidae) join the leaves one above the other by silken threads and feed on them and the damaged portion gradually dries up. The larva is very active, remains inside a tunnel formed of excretory matter and silk, wriggles out when disturbed.

### Management Measures

Since damage resulted by these pests is very less, spraying may not be required. Besides, natural enemies including parasitoids take care of these pests. *Cotesia* sp. (Braconidae) and *Chrysocharis* sp. (Eulophidae) parasitize larvae of *C. tiselae* to a great extent. But under severe incidence, spraying of quinolphos (2 ml/lit) or profenophos (1.5 ml/lit) or monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) on affected plants manage this pest.

### d. Thrips

#### (i) Leaf Thrips (*Selenothrips rubrocinctus* Giard (Thysanoptera: Thripidae), *Rhipiphorothrips cruentatus* Hood and *Retithrips syriacus* (Mayet))

Thrips are minute worm like insects damage the crop by sucking the plant sap and present throughout cashew growing regions. Attack on tender foliage of cashew by thrips results in silvery leaves (Ananthakrishnan, 1984, Ayyanna *et al.*, 1985; Jena *et al.*, 1987). Adults of *S. rubrocinctus* are dark brown and about 1-2 mm long. Nymphs are pale yellowish with a red band around the middle of their body. Tiny eggs are laid singly into the lower epidermis and covered with black excrement of adults. Egg period lasts between 3-10 days depending on the temperature. Nymphs are wingless, vermiform, carry a drop of excrement at the anal end, while adults are winged. The nymphal, pre-pupal and pupal period lasts for 10, 1 and 2-3 days, respectively (Jena, 1990). Immature stages of *S. rubrocinctus* are abundant on the older leaves than on young leaves while adults are present both on young and old leaves (Cavalcante *et al.*, 1975). In Ivory Coast also, *S. rubrocinctus* is serious and egg, nymphal and adult period lasts for 10, 12 and 25 days, respectively. The nymphs of *R. cruentatus* are white when they hatch, but pale red markings develop soon. The female thrips are 1.2 to 1.5 mm long, blackish-brown in colour, with yellow legs while antennal segments and the forewings are pale with yellowish veins. Whereas, nymphs of *S. dorsalis* are pale or cream coloured and adults are about 1.2 mm long with dark wings.

Among the thrips, *S. rubrocinctus* is very serious in nursery and young cashew plantations. In seedlings, initially it attacks lower leaves and cause premature leaf fall, stunting and finally drying of seedlings (Pillai *et al.*, 1976). In grown up plants, it damages young leaves, shoots, inflorescence and flowers and is more active during summer months (Mutter and Bigger, 1962). The infested leaves become pale brown and slightly crinkled with roughening of the upper surface. Honeydew excretory products from the thrips give rise to black sooty mould. In severe cases, shedding of leaves occurs. Leaves infested by *R. syriacus* become silvery white initially, later turn into pale brown, crinkle with roughening of upper surface and fall prematurely.

**(ii) Flower thrips: (*Scirtothrips dorsalis* H. (Thripidae), *Rhynchothrips raoensis* G. (Phlaeothripidae), *Haplothrips ganglbaueri* (Schmutz) (Phlaeothripidae), *H. ceylonicus* Schmutz (Phlaeothripidae), *Thrips hawaiiensis* (Morgan) (Thripidae), and *Frankliniella schultzei* (Trybom) (Thripidae))**

Flower thrips attack flowers, apples and nuts. Infestation causes shedding of flowers, immature fruit drop, formation of scabby as well as, malformed apples and nuts (Gowda *et al.*, 1979 and Rai, 1984). Occurrence of different species of thrips, seasonal incidence and extent of damage on cashew are studied *viz.*, *R. raoensis* (Abraham, 1958, Ayyanna *et al.*, 1985, Patnaik *et al.*, 1987, Thirumalaraju *et al.*, 1991), *S. dorsalis*, *H. ganglbaueri*, *T. hawaiiensis* (Ayyanna *et al.*, 1985), *H. ceylonicus* and *F. schultzei* (Patnaik *et al.*, 1987). Among the flower thrips, *S. dorsalis* and *R. raoensis* are prevalent in the East coast regions of India, whereas in West coast regions, *H. ceylonicus* and *F. schultzei* are prevalent (Patnaik *et al.*, 1987). Up to 15-25 per cent fruit drop is noticed (Gowda *et al.*, 1979). Apart from cashew, it breeds on a number of annual crops, including *Calycopteris floribunda* Lamk. (Combretaceae) a common shrub in many cashew plantations (Sundararaju, 1984). In Karnataka, *S. dorsalis* (75.4 per cent) is dominant than *R. raoensis* (24.6 per cent). The initiation of population buildup of both the species occurs at the time of flower bud initiation in cashew *i.e.*, first fortnight of November reaches its peak during February and completely disappears after May. Cashew varieties that bear off-season flowers have continuous infestation of thrips. In Odisha, there is an increase in population of flower thrips from October and reaches its peak during first fortnight of December (Jena *et al.*, 1987).

### Management Measures

There are several predators like various syrphids (*Paragus* sp.), coccinellids (*Pseudospidemerus circumflexa* Mots., *Menochilus sexmaculata*, *Coccinella transversalis*, *Scymnus* sp., *Illeis cincta*), lace wing bugs etc that take care of this pest. Spraying of monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) or dimethoate (2 ml/lit) or carbaryl (1 g/lit) is effective for managing thrips.

### e. Leaf and Blossom Webber

#### ***Lamida (Macalla) moncusalis* Wlk. (Pyralidae: Lepidoptera)**

Male moths are dark, fuscous and the females are green. Eggs are deposited ventrally on tender leaves and occasionally on tender shoots either singly or in groups of 5-6. This pest is distributed in all cashew growing areas especially East coast tracts of India. Infestation occurs during post monsoon flushing period (September - October) and flowering period (February- March). The egg, larval, pre-pupal and adult stages last 4-7, 16-22, 9-15 and 3-6 days, respectively (Murthy *et al.*, 1974, Rao *et al.*, 2002, Panda, 2013). The caterpillars feed on the terminal leaves of new shoots and blossoms after webbing them. Presence of webbing on terminal portions, with clumped appearance, and drying of webbed shoot/inflorescences are noticed. Galleries of silken webs reinforced with plant scraps and castings, indicate the presence of caterpillars (Ayyanna *et al.*, 1985; Satapathy and Panigrahi,

1995; Sundararaju, 2007). It occurs sporadically and can cause damage between 25-60 per cent (Dharmaraju *et al.*, 1975). In Andhra Pradesh, maximum infestation occurs during second week of May (Subba Rao *et al.*, 2006), whereas in Karnataka, it is noticed during January (Thirumalaraju *et al.*, 1991). Increase in temperature and fall in relative humidity is congenial for the pest outbreak (Ramadevi and Radhakrishnan, 1991, Subba Rao *et al.*, 2006).

### Management Measures

In East coast regions, leaf and blossom webber is parasitized by braconids (*Apanteles* spp.), elasmid (*Elasmus* sp., *Elasmus johnstonii* F.) and a tachinid fly (*Blepharella lateralis*) in Andhra Pradesh and Odisha and a maximum of 50 per cent parasitism has been reported. While in Kerala, *Apanteles* sp. and *Avga choaspis* (Nixon) (Braconidae) occur as parasitoids on leaf and blossom webber. The green lace wing, *Chrysoperla* sp. also predate on this pest. Spraying of monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) can manage this pest.

### f. Hairy Caterpillars

#### ***Metanastria hyrtaca* Cram (Lasiocampidae: Lepidoptera) and *Lymantria ampla* Wlk. (Lymantridae: Lepidoptera)**

Plenty of hairy caterpillars damage cashew, in which, *M. hyrtaca* and *L. ampla* cause severe sporadic defoliation in cashew. The caterpillars are capable of defoliating the cashew trees completely leaving only bare branches. *M. hyrtaca* occur sporadically and attack isolated trees. Egg, larval, pupal and adult period are 9, 33-35, 12 and 1-6 days, respectively (Nair *et al.*, 1974; Arjuna Rao *et al.*, 1977). The early instars of *M. hyrtaca* are gregarious feeders on tender foliage and the full grown caterpillars feed voraciously on mature leaves as well. During day time they congregate in large numbers on the ground under dry leaves near the base of the tree, in crevices of bark or lower parts of well shaded branches and are capable of complete defoliation of young trees (Nair *et al.*, 1974).

The other hairy caterpillars like *Euproctis* spp. (Lepidoptera: Lymantridae) viz., *E. fraterna* Moore, *E. scintillans* Walker and *E. subnotata* scrape the green tissues when young and start defoliating the leaves and inflorescence branches and also feed on the shell of the nut in the tender green stage and tender apples (Rai, 1984; Sundararaju, 1984). Full grown larvae of *E. fraterna* are stout, dark reddish-brown thickly covered with whitish hairs with a pair of dark tufts on either side of the head and one on the anal segment. While full grown larvae of *E. scintillans* are stout, dark-brown with tuft of fine hairs. A pale yellow strip runs down the back and on the first abdominal segment a thick tuft of blackish hairs is seen. The light brown moths of *Diacrisia obliqua* Walker (Lepidoptera: Arctiidae) lay 400- 1200 spherical, pale yellow eggs in small clusters that hatch in about 8-10 days. Larva is black and yellow with long, black and white hairs, and several yellow bands are seen on the body. While, *Estigmene lactinea* Cramer (Lepidoptera: Arctiidae) batches on the leaves or in soil. The caterpillars are active, dirty black and the body is suffused with black and yellow hairs arising from warts set in a ring around the middle of each segment.



## Management Measures

Braconids such as *Aleiodes* spp., *Apanteles oblique*, the chalcid, *Brachymeria poithetrialis* and the tachinid flies such as *Blepharipa* sp., *Carcolia* sp., *Exorista* sp. and *Palexorista* sp. are the parasitoids recorded on *L. ampla*. While, *Perilampus microgastri* Ferr (Perilampidae) is a parasitoid recorded on *M. hyrtaca* Cram. Larvae of *E. scintillans* are parasitized by *Apanteles euproctisiphagus* (Braconidae). Spraying is required only when severe defoliation and marked infestation on panicles is noticed. Insecticides including Monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) effectively manage this pest.

## g. Loopers and Semiloopers

### ***Oenospila flavifusata* Walker, *Thallasodes quadraria*, *Hyposidra talaca* (Walker) and *Pingasa ruginaria* Guenee (Geometridae)**

The defoliating loopers are very common during the new flush period from August to January causing severe defoliation (Rai, 1984). Tiny reddish eggs of *O. flavifusata* are laid on margin of tender leaves and they hatch in about 5 days. Young caterpillars have reddish tinged body, green in colour. Larval period lasts for about 15 days and they pupate within leaf folds. Pupal stage lasts for 10 days. The eggs of *T. quadraria* are laid on the leaves that hatch in 3-5 days. The larvae are pinkish, slender and assume a characteristic pose oblique to the stem on the twigs and are mistaken for part of a twig or leaf petiole. Pupal period lasts 6-8 days. Larva of *P. ruginaria* is green having white cross markings throughout the body. In adults, the patterns on its wings would enable it to blend against the bark of a tree, especially one with lichen growth. *H. talaca* is recorded as an emerging pest in cashew (Chutia *et al.*, 2011) having wide host range including various forest trees, crops and weeds. Egg period of *H. talaca* is 6-7 days while, larval and pupal period lasts for 15-18 days and 7-10 days, respectively. The geometrids are sporadic in occurrence but they do cause considerable damage. They defoliate the tender leaves from the margins. The tender shoots damaged by *O. flavifusata* are left only with portions of midribs. Besides leaves, the larvae of *H. talaca* damage inflorescences also.

## Management Measures

Since these pests cause sporadic defoliation, spraying is generally not required against this pest. But if necessary, insecticides like monocrotophos (1.5 ml/lit) or profenophos (1.5 ml/lit) can be sprayed to manage the pest.

## h. Leaf Beetles and Weevils

### ***Monolepta longitarsus* Jac., *Neculla pollinaria* Baly, *Lypesthes* sp. (Chrysomelidae: Coleoptera), *Deporaus marginatus* (Coleoptera: Attelabidae)**

Several chrysomelid beetles attack cashew especially during monsoon as well as post monsoon flushing period. Among them, *M. longitarsus* and *N. pollinaria* are important defoliators. While, *D. marginatus* occur occasionally on tender shoots and nursery plants. During rainy season (June-August), the chrysomelid leaf beetles and weevils defoliate cashew voraciously. *M. longitarsus* is a regular pest in the west

coast regions during the south west monsoon. They appear abundantly especially on young trees and skeletonise the leaves which gradually dry up. Tender shoots are also attacked that finally dry off. When nursery seedlings are attacked, the entire seedlings dry up. A group of 60-75 beetles are capable of causing complete drying of shoots in 2-3 days. It is also severe on current season limb pruned trees. These beetles also damage tapioca (Rai, 1984), *Terminalia arjuna* and *T. paniculata* Roth (Sundararaju, 1984). While, adults of *N. pollinaria* and *Lypsthes* sp. also attack the postharvest flushes causing defoliation and drying up of the shoots. Scrapping of the bark of tender shoots by the beetles appears as linear depressions. Adults of *D. marginatus* weevils remain on the lower side of the leaves and scrape the leaf surface making minute feeding holes which appear as 'windowpanes' on young leaves.

In Odisha, another beetle, *Microserica quadrinotata* Moscr (Melolonthidae: Coleoptera) occurs on cashew from June-October causing up to 30 per cent leaf damage during peak infestation on September (Jena *et al.*, 1985; 1986a). The adults, cause skeletonization of the leaf by scraping chlorophyll that turn red and finally dries up. The beetles also infest mango, neem, acacia, basal, *Crotalaria* and cucurbits. Similarly, in Odisha an ashy weevil, *Peltotrachelus pubes* Faust. (Curculionidae: Coleoptera) feeds on the tender leaves causing up to 15 per cent leaf damage (Jena *et al.*, 1986b). Besides, leaf rolling weevil, *Arodepus marginatus* (Attelabidae), Curculionid weevils *viz.*, *Amblyrrhinus poricollis* Schoenherr, *Apion amplum* Faust, *Apoderus tranquebaricus* Fab., *Myllocerus discolour*, cetoniid beetle, *Oxycetonia versicolor* Fabricius and other chrysomelid beetles *viz.*, *Basilepta flavicorne* Jac., *Hyperaxis albostriata* Mots and *Pagria costatipennis* Jac also defoliate cashew occasionally.

### Management Measures

Spraying of any systemic or contact insecticide manages these pests. Spraying of chlorpyrifos (1.5 ml/lit) or monocrotophos (1.5 ml/lit) or quinolphos (2 ml/lit) or lambda- cyhalothrin (0.6 ml/lit) could cause mortality of the beetles in a short period.

#### i. Other Defoliators

*Bombotelia jacosatrix* Guenee (Noctuidae: Lepidoptera) is a leaf eating caterpillar that feed tender leaves from the margins. Early instars are gregarious and at the later stages they feed on the entire leaf, leaving only the midribs. Eggs are laid in rows on leaf margins of tender leaves; they hatch in 3-5 days. Larvae are greenish, striped with reddish-brown spots and larval period lasts for 11-18 days. Pupation takes place in a silken cocoon inside the leaf folds and adult emerges in 9-15 days.

Caterpillars of *Orthaga exvinacea* Hampson (Pylalidae: Lepidoptera) web together tender shoots and leaves, live within the webs and feed on the leaves. Several caterpillars are found in a single webbed-up cluster of leaves. Presence of silken webs reinforced with pieces of plant parts on terminal portions and blossoms as well as dried up appearance are the symptoms of its infestation. Eggs are yellowish green that hatch in 4-5 days. Caterpillars are slender, pale-green with dark bands, pupates in 28-33 days. Pupation takes place in silken cocoon. The pupa is reddish-brown and lasts for 11-14 days. The larvae of *Spodoptera litura*

F., *Helicoverpa armigera* Hubner (Noctuidae: Lepidoptera) and bag worm, *Dappula tertia* Templeton (Psychidae: Lepidoptera) also defoliate cashew in certain pockets of India. Besides, the caterpillars of Tassar silk moth, *Antheraea paphia* L., *A. mylitta* Drury and *Circula trifenestrata* Helfer (Saturniidae: Lepidoptera) are also sometimes, noticed on cashew that defoliates voraciously (Rai, 1984, Vanitha *et al.*, 2015). The wild silk moth *C. trifenestrata* occurs in swarms during September-October causing severe defoliation. They feed voraciously for more than a month and pupate in golden yellow hairy silken cocoons which are found in masses inside group of leaves during November (Sundararaju, 1992).

### Management Measures

Spraying of monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) can effectively manage these defoliators.

### j. Stem and Bark Feeders

Apart from CSRB, there are also other pests damaging cashew stem and bark. The caterpillars of *Inderbela tetraonis* Moore (Arbelidae: Lepidoptera) make a small residential hole on the wood normally where the branches fork and make superficial galleries inside which they feed on the tissues. The presence of winding galleries on the bark made of powdered bark, faecal pellets and silk webbed together indicates this pest attack. Feeding damage in small branches results in drying up of branches. The eggs are laid under loose bark that hatch in 8-10 days. Larvae are pale brown with dark head move along the branches concealed under the gallery. Larval period lasts even up to 10-11 months while, pupal period lasts for 15-25 days (Rai, 1984). Adults are stout, pale brown moths with wavy grey markings on the wings.

In addition, adult beetles of *Paranaleptes reticulata* Thomson and *Stenias grisator* Fabricius (Cerambycidae: Coleoptera) girdle the cashew branches with their strong mandibles. Hence, xylem and phloem tissues are damaged; the branches above the ringed portion dry up. Adult *P. reticulata* beetle lays eggs in series of irregular incisions made in the dead wood during the dry season. Hatching grubs are yellowish, tunnel into the dead wood of the branch and cause damage. Whereas, adults of *S. grisator* are stout greyish-brown beetles having elliptical greyish spots and an eye-shaped patch on the elytra. While, coleopteran grubs of *Xystocera globosa* Oliver (Cerambycidae), *Xylothrips flavipes* (Bostrichidae), *Belinota prasina* Thunberg *Lampetis fastuosa* F. (Buprestidae), *Analeptes trifasciata* Fabricius (Cerambycidae), *Coptos aedificator* Fabricius (Cerambycidae), *Mecocorynus loripes* Chevrollet (Curculionidae) also cause bark and sap wood damage in cashew.

### Management Measures

To manage bark eating caterpillar, removal of galleries plastered on tree trunk or pouring of kerosene during early stage of infestation is suggested. In the chemical method, application of quinolphos (2 ml/lit) or dichlorvos (2 ml/lit) either by injection or by inserting a cotton swab soaked in the insecticide is the most widely used method.

## k. Apple and Nut Borer

### *Thylacoptila paurosema* Meyrick, *Hyalospila leuconeurella* Ragonet, *Nephopteryx* sp. and *Anarsia epotias* Meyrick (Pyralidae)

*T. paurosema* lays eggs on the immature fruits or nuts, and the incubation period is 3-5 days. The caterpillars are very active, dark pink in colour, measures 2-2.5 cm and the larval period lasts for 15-20 days. Larvae initially damage flowers by webbing the panicles and feed the unopened flower buds. Then they tunnel near the junction of apple and nut and bore inside the tender nuts and developing apples resulting in shrivelling and premature fall. Damaged fruits can be easily located as they have frass hanging externally at fruit and nut joint. Variable degrees of damage by this species have been reported from different cashew-growing tracts of India and damage of 10 per cent was reported by Nair *et al.* (1979). This pest also damages stored cashew nuts (Rai, 1984).

The caterpillars of *H. leuconeurella* bore through the apple from one end to the other but remain inside the apple till the fruit drops. Attacked apples generally fall down from the trees. Infested nuts become severely deformed. The egg, larval and pupal period lasts for 4-5, 12-17 and 9-12 days, respectively (Jena, 1990). The adult is dark-brown moth with a wing expanse of 16 mm. In a single apple, up to 6 caterpillars of different sizes are seen (Basu Choudhuri and Misra, 1973). Similarly, *Nephopteryx* sp. (Pyralidae: Lepidoptera) is common in Tamil Nadu and Andhra Pradesh (Ayyanna *et al.*, 1985, Dharmaraju *et al.*, 1975) attacking fruits at all stages of development causing up to 60 per cent of nut damage. Initially, the larvae scrape the epidermis of tender nuts and apples. Then, the young larvae move to the point of attachment of nut and apple and bore into apples and nuts. The entry hole is minute and plugged with the excreta. The infested fruits shrivel and drop prematurely, while, the nuts do not develop further and dry up. The larval period is 15-33 days. In one fruit, around 3-5 larvae were found (Rai, 1984). Larva pupates in earthen cocoon adult emerges in 8-10 days (Jena, 1990).

In south India, *Anarsia epotias* Meyr. (Gelechiidae) and *Helicoverpa armigera* (Noctuidae) were found as apple and nut feeders (Basu Choudhuri and Misra, 1973; Ramadevi and Ayyanna, 1988). The larva of *A. epotias* binds dry inflorescences to the side of the apples and nuts hanging adjacently and nibbles them continuously. At times, the caterpillars make galleries even inside the nut. The female lays 50-60 eggs singly or in groups of 10-20 that hatch in 3-4 days. Pupation takes place in larval tunnels of the attacked shoot, in crevices of the branches, twigs, at the cut end of branches or within the galleries in the apples. Pupal period is 7-10 days and the total life cycle is completed within 27-29 days (Basu Choudhuri and Misra, 1973). Besides, larvae of *Orthaga exvinacea*, *L. moncusalis* and *Euproctis* spp. also damage tender nuts and apples, however, they are considered to be external feeders. If proper management is taken up against flower and fruit pests, more than 60 per cent yield loss can be avoided (Sundararaju, 2007).

## Management Measures

Removal and destruction of infested portions of inflorescences as well as infested apples and nuts having larvae can be followed to prevent spread of the pest. Three larval parasitoids viz., *Panerotoma* sp. (Braconidae), *Trathala flavorbitalis* (Ichneumonidae) and one unidentified tiny dipteran fly occur on apple and nut borer larvae and a maximum of 46.2 to 50 per cent parasitism has been recorded under field conditions. Spraying of carbaryl (1 ml/lit) or lambda cyhalothrin (0.6 ml/lit) or quinolphos (2 ml/lit) or dichlorvos (1 ml/lit) is found effective for apple and nut borers.

### 1. Mealybugs

#### ***Planococcus citrii* Risso, *Planococcus lilacinus* Cockrell and *Ferrisia virgata* Cockrell, *Planococcoides robustus* Ezzat and Meconnel**

Mealybugs are potential pests in case of cashew. *F. virgata* are small plumpy, soft insects, body is covered with number of white waxy filaments all over, with two pronounced long waxy processes at the posterior end. A pair of dark submedian stripes is also present. Nymphs of *P. citrii* are pale yellow without waxy coating. Adult females are slightly elongate, ovate, 5-7 mm long but covered with white mealy wax including the appendages. It is presently distributed in Karnataka, Kerala, Tamil Nadu, but severe in Konkan region and Goa. Egg masses of *F. virgata* remain under the females till the young ones hatch out. A female lays 100-300 eggs in 3-4 weeks. Eggs hatch in 3-4 hours and the nymphs develop as adults in about 26-47 days. Adults live for 14-21 days. The pest is prevalent during December- April. Mealybug colonies develop on young vegetative shoots, leaves, inflorescence, and tender nuts and fruits. Damaged flowers wither and dry, while the fruits shrivel, under develop or sometimes dry up. Due to honey dew secretion by mealy bugs, sooty mould develops on the affected portions.

## Management Measures

Removal and destruction of mealy bug infested plant parts help to minimize their infestation and spread. *Apanteles* sp. has been reported as a parasitoid on *F. virgata*, besides *Blepyrus insularis* Cameron. In Kerala, up to 35 per cent parasitism has been reported in *F. virgata* to be caused by *Aenasius advena* Campere (Encyrtidae). In Karnataka also, *A. advena* could cause upto 50 per cent parasitism in *F. virgata*. If essential, spraying of profenophos (2 ml/lit) or chlorpyrifos (2ml/lit) or dimethoate (2 ml/lit) or thiamethoxam (0.6 g/lit) or imidacloprid (0.6 ml/lit) may be followed to manage mealy bugs in combination with fish oil Rosin soap at 20 g/lit.

### j. Aphids

#### ***Toxoptera odinae* van der Goot and *Aphis gossypii* (Aphididae: Hemiptera)**

Aphids are tiny (1-3 mm), soft, brownish in colour with prominent cornicles and found in groups during December – April and June. They reproduce mostly by parthenogenetic vivipary and also by sexual reproduction. Nymphs are tiny, complete four instars in a period of 9-16 days and become adults. A single female

can produce around 35-50 young ones in a short period. Though aphids are seen in huge numbers on leaves, shoots, inflorescence and immature nuts, the feeding seldom results in damage.

### Management Measures

This is not a serious pest at present, but intense damage could cause drying of infested parts and sooty mould growth. Removal and destruction of aphid infested plant parts help to minimize their infestation and spread. There are several predators like syrphids (*Paragus* sp.), coccinellids (*Pseudospidemerus circumflexa* Mots., *Cryptolaemus montrouzieri*, *Menochilus sexmaculata*, *Coccinella transversalis*, *Scymnus* sp., *Illeis cincta*), lace wing bugs, mantispid flies etc. control this pest. If necessary, spraying of dimethoate (2 ml/lit), phosphomidon (2 ml/lit), or methyl demeton (2 ml/lit) can be taken up.

### 3. Storage Pests

In general, regular practice of proper sun drying of raw cashewnuts for 2-3 days after harvest kills most of the pest stages. Besides, raw cashewnuts are seldom stored more than two to three months and are rarely damaged by insects. But, processed cashew kernels are damaged by many insect pests during storage. Infestation by insects causes losses in terms of quality and quantity of cashew kernels besides changing the chemical composition affecting its nutritive value. Around twenty species of beetles, five species of caterpillars and some psocids and mites are reported to infest cashew kernels during storage. Among these, *Ephestia cautella* (Wik.), *Corcyra cephalonica* (St.) (Pyralidae), *Tribolium castaneum* (Herb.) (Tenebrionidae) and *Necrobia rufipes* (De C.) (Cleridae) damage directly the kernels. While other insects contaminate the cashew kernels by their excreta (Nair *et al.*, 1985, Vijay Singh, 1988a, 1988b; Vishnu Priya, 2011).

The biology of *T. castaneum*, *C. cephalonica* and *Oryzaephilus surinamensis* on cashew kernels have been studied. Egg, larval, pupal and adult period lasts for 4, 29.36, 10.04 and 28.6 days, respectively for *T. castaneum*. Egg, larval, pupal and adult period of *C. cephalonica* are 5, 29.59, 12.24 and 10.67 days respectively, while 4, 19.7, 7.09 and 100 days, respectively for *O. surinamensis*. Grubs and adults of *Trogoderma granarium* infest the kernels damaging the entire soft portion. Infestation of *T. castaneum* reduces the levels of proteins, fat, carbohydrates and ash contents of cashew kernels. Upon pest damage, energy values of kernels drop down significantly and the moisture content increases. Hence, strict sanitation of the processing sheds and premises, keeping processed nuts in closed containers, undertaking peeling, grading and packing in quick succession are suggested as measures to control these pest infestations.

### 4. Cashew Pest Management: Some Considerations

- ☆ In general, plant protection measures taken up against tea mosquito bug take care of the infestation of most of the foliage pests. Spraying is required, only under severe infestation.

- ☆ In young cashew plants, removal of different stages of pests like egg masses/egg laden leaves or shoots, caterpillars or grubs, pupa or cocoons from the infested plants gradually reduces the pest population.
- ☆ Under unsprayed conditions, an array of predators *viz.*, spiders, ants, reduviids, coccinellids, neuropterans, hemipteran bugs and praying mantids take care of many of the cashew pests. But so far, very little progress could be made in biological control options.
- ☆ Red ants (*Oecophylla smaragdina*) are the potential biocontrol agents in cashew plantations that feed on bugs, caterpillars, hoppers, moths etc. Apart from predators, there are many parasitoids on several cashew pests. Hence, indiscriminate spraying may be avoided.
- ☆ Tree to tree spraying is to be advocated, instead of whole plot spraying to avoid environment pollution. Besides trees harbouring ant nests especially red ants should be spared of spraying to allow ants to take care of pests naturally. Avoiding spraying on the non-target areas such as trunk, tree bases etc can help to protect some natural enemies.
- ☆ Neem oil (3-5 per cent), Karanj (*Pongamia*) oil @ 2 per cent and Fish Oil Rosin Soap and Neen seed kernel extract (NSKE) (5 per cent) are some of the botanical preparations can be effective against many of the cashew foliage pests like leaf miners and leaf feeding caterpillars. While using botanicals, emulsifiers (soap water/bar soap 0.5 per cent @ 5 g/lit or teepol (0.1 per cent) should be used in the spray fluid.
- ☆ Spraying should be done before 9 am or after 4 pm in order to save non-target pollinators. Rotation of insecticides between sprays is advised to prevent development of resistance to any particular pesticide.
- ☆ Monitoring pests of weeds in cashew plantations and their mangemnet is required, since plants like *Terminalia paniculata*, *Chromolaena odorata*, *Melastoma malabathricum* and *Getonia floribunda* are not only competitors of cashew but also serve as host plants for few cashew pests including TMB.

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