Nazeer Ahmed • Shabir A. Wani • W. M. Wani

APPLE

Production & Value Chain Analysis

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The Editors

Dr. Nazeer Ahmed, is Vice Chancellor, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), J&K. Dr. Ahmed served in various capacities as Scientist, Senior Scientist, Associate Director Research, Professor and Head, Dean Agriculture, Director Resident Instruction cum Dean Post Graduate Studies at SKUAST-K and Director, ICAR-Central Institute of Temperate Horticulture, Srinagar. During his 32 years of service, he has contributed significantly as a teacher, researcher, extension worker and administrator. Dr. Ahmed has published more than 300 research papers in National and International Journals and released 34 varieties and hybrids in Temperate Horticultural crops. Dr. Ahmed has guided many Master's and Ph.D. scholar's and is recipient of several prestigious awards and honours including Rajbhasha Gaurav Award, Dr. R. S. Paroda Award, Dr. M. H. Marigowda National Endowment Award, Dr. Kriti Singh Gold Medal and Vijay Shree Award.

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Foreward

When India attained Independence from the colonial rule, it faced serious problem of hunger and under nutrition. A part of the shortage was met through imports. By the mid-1960s food shortage turned quite serious and imports also became very difficult. In the wake of this country embraced the strategy to attain self-sufficiency in food-grains production. The green revolution technology which became available during late 1960s helped the country to achieve breakthrough in productivity and production of staple food. In a few years India started experiencing higher growth in food grain production as compared to the growth in its population. This made the country self-sufficient in staple food production followed by surplus in cereals.

After sufficient availability of rice and wheat the demand for food started diversifying towards fruits and vegetables which also offered higher incomes compared to food grains. At the same time growth rate and income from cereals came under stress due to various reasons. It was then considered appropriate to promote diversification towards fruits and vegetables for raising income of the producers and to match supply with the changes in demand.

The scope of diversification towards horticultural crops varies across region. Horticulture, particularly fruit cultivation is both ecologically

and economically superior to other crops in mountain regions. The north-western Himalayan States of India are found to have immense potential to raise income and employment opportunities in the Horticulture sector. The climatic conditions in this region particularly in the state of Jammu and Kashmir offer good scope for cultivation of a variety of temperate fruits like apple, cherry, pear, peach, plum, apricot, almond & walnut. Accordingly, apple industry has emerged strong and established its credibility in improving farmer's income, generating employment and in enhancing exports, besides providing household livelihood security. With the growing consumer awareness about healthy eating, and established perceptions about apples as a healthy and flavorful fruit, the Indian market for apples is expanding. To meet this rapidly growing demand through domestic supply, there is scope in the Himalayan states for both horizontal and vertical expansion of apple cultivation. This requires access of farmers to modern production technology and efficient value chains in apple. In this direction the present edited book "Indian Apple: Production and Value Chain Analysis" is a valuable addition to the knowledge on production and marketing of apple. The book covers status, achievements and future R&D strategies on different issues concerning Indian Apple vis-à-vis global advancement. The information contained in this book will meet the technical and economic requirements of researchers, teachers, students, policy planners, development workers and farmers of Indian apple industry. The editors need to be commended for their efforts to provide such useful and sought-after information.

(Prof. Ramesh Chand)

Preface

During the first few five year plans, priority was assigned to achieve self-sufficiency in food-grains production. However, over the years, agricultural growth is not keeping pace with other economic sectors and is lagging far behind than that of the manufacturing and service sectors. The share of agriculture in GDP has fallen steeply although dependence on agricultural sector for livelihood remains quite high. Government of India has set a policy target of doubling farmers' income by 2022. For increasing farmers' incomes some of the important options delineated included agricultural diversification towards more remunerative commodities, such as horticulture, livestock and fish. In the north-western Himalayan States of India, the obligation of providing income and employment opportunities fall heavily on the Horticulture sector. Owing to various mountain specificities characterizing the region constraints are imposed for raising productivity of field crops and generating income for smallholder**.** The region offers good scope for cultivation of horticultural crops, covering a variety of temperate fruits like cherry, pear, peach, plum, apricot, almond & walnut in general and apple is considered most important in particular.

In the north-western Himalayan States of India, apple industry has emerged as an important sector for diversification towards horticulture and has established its credibility in multiplying farm income. Apple crop has witnessed most significant increase in the region contributing to the shifts from paddy and other field crops at a very high pace with bright prospects towards this sector. Important reason being handsome returns to the farmers with shortage of water at summer season, apple cultivation compared to field crops requires it at lesser levels. Apple production has

developed as an industry and more and more land is apportioned to this sector each year. While the cereal based production system provides household nutritional security. It is ability of apple based value chain to generate sufficient income to provide livelihood security even to smallholder. Apart from the government schemes, the more profound factor for diversification of regions agriculture towards apple sector is driven by comparative advantage principle. Among the temperate fruits, apple is coming up in a big way through horizontal and now vertical expansion. To meet the growing demand, Govt. of India has even relaxed apple import norms and has allowed in bound shipment of fruits through sea port and air ports in Kolkata, Chennai, Mumbai and Cochin.

Timely and reliable information as well as analysis is vital for planning and decision making. In this direction the present edited book "Indian Apple: Production and Value Chain Analysis" is an initiation of a process to create a knowledge house; wherein galaxy of researchers/contributors with diverse areas of specialization have deliberated upon various issues characterizing Indian apple. The book is a synthesis of 30 lead papers contributed by R&D workers/experts/policy planners from different institutions/organizations. It covers status, achievements and future R&D strategies on different issues concerning Indian Apple vis-à-vis global advancement in the value chain. The issues covered range from research needs, innovative technologies, genetic resources, nursery management and crop improvement, disease and pest management, mechanization, pre and post-harvest management apart from economics, finance, marketing & trade.

We are highly thankful to Prof. Ramesh Chand, Hon'ble Member, NITI Ayog, Government of India, by sparing his valuable time and contributing forward of this publication. We also take this opportunity to thank all the contributors from different universities, institutes and organizations from India and abroad who have responded to our request to share results of their independent studies. It is hoped that knowledge shared by the contributors in the book will be of interest and benefit the researchers, teachers, students, policy makers, development workers and farmers involved in apple cultivation.

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Chapter 17
Insect-Pest Complex and Integrated Pest Management on Apple in Jammu and Kashmir, India

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1. INTRODUCTION

Jammu and Kashmir is the largest producer of apple in the country because of its best temperate climate suited for its production as compared to the rest of the Indian Union. The history of apple cultivation in Kashmir is traced to the old literature. With the introduction of exotic varieties of apple in Kashmir valley, new insect pests emerged, which include San Jose scale, European red mite, Codling moth and Woolly apple aphid. The establishment of these pests and subsequent losses made by these pests are alarming to the fruit growers. These pests cause losses both directly and indirectly. The direct losses are the reduction in fruit damage, quality and quantity of apple fruits and indirect losses are the costs incurred for their management. Due to the lack of well-organized and a precise quarantine system for insect pests of apple in India, the exotic pests are of major concern. Although thrips, leaf rollers and tussock moth also infest apple in Jammu and Kashmir, the losses by these insects are non-significant. As such it is necessary to depict the nature of infestation, identification and detection of different stages of apple pests and their distribution in India. The insect pests which have prime importance on apple in Jammu and Kashmir and other states of Indian union are given in Table 1.

2. IMPORTANT INSECT -PESTS

(a) San Jose Scale

Scientific Name : *Quadraspidiotus* perniciosus (Comstock)

Family : Diaspididae

Order : Hemiptera

(I) Distribution

This pest has been introduced in Kashmir valley and Himachal Pradesh during the first decade of twentieth century.

(i) Detection and identification

Nymphs: Ovoviviparous females give birth directly to the young ones that emerge out, under the scale coverings. One female is capable of giving birth to 200-400 nymphs. These tiny yellow crawlers are mobile free living for 12-24 hours and wander in a random fashion. Upon settling in the preferred places on the host tree, the crawlers insert their mouthparts and suck the sap from tender shoots/branches of the host tree. While feeding, they secrete a white waxy material and this stage is known as a white cap stage. The waxy material latter changes to black colour and this stage is named as the black cap stage. The cover of the scale turns into various shades, grey and black.

Adult: After the first molt, male and female (immature) scales are easily distinguishable. The female covering is circular and that of the male is elongated. Males are winged and females are non-winged. The colour of the adult male is tiny yellow. Males mate with the non-winged females, which are covered by grey scales. The yellow lemon coloured female is visible when the covering is lifted. Female scales are very prolific over a 6-week period and can produce approximately 400 young nymphs. It takes 25 days for males to mature and 31 days for females. In Kashmir, two complete summers and third partial generations occur in a year.

Table-1: Important insect-pests and their status on apple in Kashmir Valley

S. No	English Name	Scientific name	Damaging stages	Status of the pest
1.	San Jose scale	*Quadraspidiotus perniciosus*	Both Nymphs and adults	Key pest

2.	European Red Mite	*Panonychus ulmi*	Both Nymphs and adults	Key pest
3.	Codling moth	*Cydia pomonella*	Caterpillar	Key pest in Ladakh
4.	Indian Gypsy moth	*Lymantria obfuscate*	Caterpillar	Minor pest
5	Woolly apple aphid	*Eriosoma lanigerum*	Both nymphs and adults	Major pest
6.	Tent Caterpillar	*Malacosoma indicum*	Caterpillar	Sporadic pest
7.	Apple stem borer	*Aeolesthes sarta*	Grubs	Major pest
8.	Bark beetle	*Scolytus nitidus*	Grubs	Minor pest
9.	Apple leaf miner	*Lyonetia clerkella*	Larvae	Minor pest

(II) Nature of infestation

San Jose scale nymphs and females attack the above ground parts. The spots on the fruits show characteristic symptoms of purplish red colour. While the infested branches show ash grey symptoms, sucking of the tree leads to reduced growth and eventually death of the tree.

San Jose scale infestation on apple twigs and on apple fruit

(III) Monitoring and surveillance

San Jose scale infestation can be easily visualized on the infested branches and fruits as they turn grey or black and ultimately, ash coloured. The sticky tape should be pasted on small twigs or limbs around the infested areas to determine when crawlers are active. Use degree day model to observe the emergence of San Jose scale male adults and crawler emergence. Daily monitoring is necessary to set a biofix for the San Jose scale adults (UC IPM, 2005). The lower developmental threshold for San

Jose scale is 10 °C. Application of dormant season spray oils is effective for controlling the San Jose scale population (Sofi and Hussain, 2008) and the second insecticidal treatment is advised in the first week of May, at the time of crawler emergence (unpublished data). Monitor pruned twigs when winter pruning is done especially on twigs from tree tops to estimate the over wintered population.

(b) European Red Mite

Scientific Name	:	*Panonychus ulmi* (Koch.)
Family	:	Tetranchidae
Order	:	Acari

(I) Distribution

In India, It is widely distributed throughout Jammu and Kashmir, Himachal Pradesh, Utter Pradesh and Meghalaya.

(i) Detection and identification

Egg: Eggs are laid during winter and summer. The eggs laid during winter are known as overwintered eggs. Eggs are laid on fruit spurs, twigs, near the base of buds and tree crevices. The colour of the eggs is brick red with a stalk. The overwintered eggs hatch during spring. The summer eggs are laid on the foliage, however, if heavy infestation of mite is noticed, eggs could be found on fruits also. The summer eggs are smaller than overwintered eggs. The average hatching of eggs varies from 6.7 to 14.4 days.

Nymphs: European red mite possess three stages namely larva, protonymph and deutonymph. The larva is fairly larger than the egg, is orange-red in colour and can be distinguished from other stages by having only three pairs of legs. The protonymph and deutonymph are comparatively larger and posses four pairs of legs.

Adult: The adult female is brick red in colour and oval in shape with strong white bristles on the back of the abdomen. The bristles are with white bases, which appear as white spots on the back. The male is a yellowish red. The male is fairly smaller than female (UC IPM, 2008) with a pointed abdomen. Male is more cylindrical than female.

Adult Mite, *Panonychus ulmi*

(II) Nature of infestation

The mites feed into leaf cells and suck out the contents and chlorophyll by their mouth parts. The infested leaves show bronzing appearance, develop large necrotic areas, and are shed prematurely. The photosynthesis rate is also reduced.

(III) Monitoring and surveillance

Regular monitoring is important for any survey and surveillance programs. For red mite, monitoring should be done as soon as the overwintered eggs start to hatch. Mostly overwintered eggs of red mite hatch during spring season, which varies from place to place. Ten trees should be selected from one block of apple orchard and from each tree at least ten leaves should be examined using an insect hand lens. Record both the number of mites and number of leaves infested by red mite to estimate the mite density and the mite infested leaves.

(c) Codling Moth

Scientific Name : *Cydia pomonella* (Linnaeus)

Family : Tortricidae

Order : Lepidoptera

(I) Distribution

In India, its distribution is restricted to Ladakh region of Jammu and Kashmir State and is thought to have entered Ladakh from the North West Frontier province of Pakistan, where it is a serious pest of deciduous fruits.

(i) Detection and identification

Egg: Flat and pin head size eggs are transparent in colour. Eggs are laid singly by a female on the leaves and near to apple fruit. The eggs turn dark as the hatching starts. Egg period is about 6 to 14 days depending on environmental conditions.

Larva: After egg hatching, the newly emerged larva bore the fruit and feed on seeds. The larvae have a pink body and a black head. During winter, codling moth larva overwinters as full-grown larvae within thick, silken white cocoons under loose bark or fallen fruits and in the soil as well as in debris around the base of the tree (Zaki, 1999). Full grown larvae are pinkish or creamy white in colour with brown head.

Pupa: Fully developed larvae pupate in the soil, fallen fruits, on fallen leaves and mostly under the loose bark around the stem. The pupal period ranges from 10- 20 days.

Adult: *Codling* moth adults are about one inch long. Forewings are greyish dark with waxy lines and coppery areas at the tip of the wings. The body is molted greyish brown in colour. The overwintered larvae pupate in the spring and emerge out as adults during mid-May and June. The adult emergence is more often synchronized with the fruitlet stage.

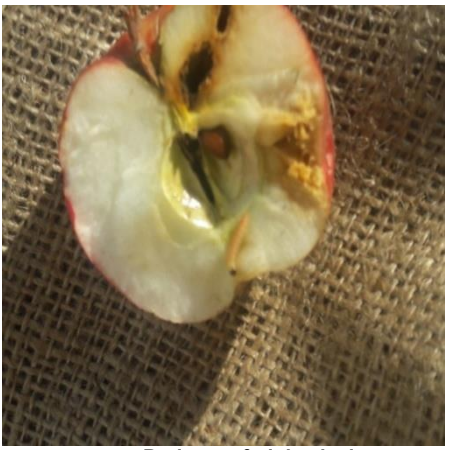
(II) Nature of infestation

Codling moth larvae bore inside the fruit and eat towards the central core of the fruit. The larvae feed on the seeds inside the fruit and create exit holes. The waste material is pushed out through the exit holes, however, the waste material may remain associated, or in the fruit that accelerates internal rotting. Codling moth larvae directly feed on fruits and the losses are more than 80 per cent of apple fruit. Under severe infestation, fruits fall prematurely.

(III) Monitoring and surveillance

Fruit damage can be estimated by observing forty fruits from an apple tree. In Ladakh, apple trees are not grown scientifically, as trees are un-pruned and scattered. Apple plantations could be found on the slopes near houses. To assess the fruit damage, at least 120 fruits are examined from the three apple trees randomly from three different sites at each location. To examine fruit injury and fruit damage, 360 fruits should be selected from each hamlet. The time for estimating the fruit damage can be done from July to October.

Fruit injury by Codling moth



Boring on fruit by the larva

As the fruit growers do not have gadgets for the application of insecticides and other IPM methods, because of socio-religious constraints in Ladakh. Use pheromone-baited traps for codling moth, these traps should be installed very close to the infested branches (Hussain *et al.*, 2015). To set the biofix for codling moth in Ladakh, trap the adult population from the first week of May. Delta traps baited with codlemone lure are effective to set the biofix and to monitor the adult population. The trees should be banded with gunny bags or cardboard sheets to monitor the first generation larvae, which scan for shelter and also monitor the overwintering larvae around these bands.

(d) Indian Gypsy Moth

Scientific Name : *Lymantria obfuscate* (Walker)

Family : Lymantriidae

Order : Lepidoptera

(I) Distribution

In India, it is distributed in Himachal Pradesh, Punjab and Jammu and Kashmir. It is now considered as a minor pest on apple in Jammu and Kashmir.

(i) Detection and identification

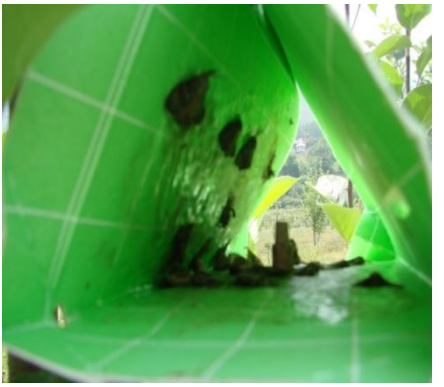
Egg: A single female lays about eggs in batches. The egg batch can be found on loose bark, tree stems of host trees, old branches, and in outdoor objects. These eggs are covered with yellowish brown. The eggs hatch from the last week of March to first week of April.

Larva: Newly hatched larvae are small and buff-coloured, but turn black within a few hours. The latter instars are hairy and blackish, with several light orange dots on the last half of the back. The total larval period lasts for 50- 66 days. The larvae remain active from the last week of March to end of May in Kashmir conditions.

Pupa: Pupae are dark brown or mahogany-coloured and are found in sheltered areas. The pupal period lasts for 4 -12 days. The pupal stage can be observed from the first week of June to mid-June.

Adult: Males are small and dark brown with blackish markings and are strong fliers. Females have atrophied wings and are unable to fly. Each female lays about 500 to 1000 eggs. These eggs are laid in batches and are covered with a tuft of hairs. The adults are active from mid-June to mid-July. The Indian gypsy moth has only one generation in Kashmir. The longevity of adults last for 3-30 days.

A. Male, B, Female



Males trapped in delta traps

(II) Nature of infestation

Caterpillars are voracious feeders and feed gregariously on leaves during the night time. Severe infestation by the caterpillars results in complete defoliation of leaves and poor quality or failure of fruit formation.

(III) Monitoring and surveillance

Monitoring of the adult population should be done when adults have started to emerge. The best time for monitoring the adult population of gypsy moth should be done by using delta traps baited with a dispar lure (Hussain *et al.*, 2015). The best time for installing the pheromone-baited traps should be started in the first week of June.

The larvae are nocturnal feeders and shelter during the day on limbs or branches of the infested tree. They cause complete leaf defoliation. To estimate the overwintered population, gypsy moths overwinter as in the egg stage, therefore, egg monitoring and survey should be carried from July to March.

(e) Wooly Apple Aphid

Scientific Name	:	*Eriosoma lanigerum* (Hausmann)
Family	:	Aphididae
Order	:	Hemiptera

(I) Distribution

In India, it is found in Punjab, Assam, Jammu and Kashmir, Karnatka, Megalya, Skim, Tamil Nadu, Utter Pradesh and West Bengal

(i) Detection and identification

Eggs: Aphids are viviparous and reproduce both asexually, parthenogenetically and sexually after mating. Sexual forms mate in winter and lay single, long, oval egg in the crevices of bark.

Nymphs: Eggs hatch in the spring into wingless, parthenogenetic viviparous females. Nymphs hibernate underground on the roots of the tree. Winter is considered as a non-reproductive period. During the onset of March, a female produces 30-116 nymphs parthenogenetically, which could be winged or wingless. Winged forms are present throughout the year and non-winged forms occur from July to October. Within 24 hours the nymphs start secreting waxy white cottony filament, hence named as a

woolly apple aphid. Nymph period lasts for 11 days in summer and 93 days in winter (Thakur and Dogra, 1980)

Adult: Nymphs and adults are reddish-brown in colour with waxy white filaments on the whole body. They feed on trunks, tender branches, and twigs of apple trees. In autumn, winged aphids develop from both the aerial and the root colonies. Both sexes are wingless. Nymphs on the trees migrate downwards towards root zone for hibernation. Multiple generations of woolly aphid occur throughout the year.

(II) Nature of infestation

Both nymphs and adults suck cell sap from trunk, branches, stems, twigs, leaf petioles bark of twigs and on roots. Knots on roots and twigs become swollen due to the feeding by this aphid. Severe infestations by this aphid lead to yellowish foliage and short fibrous root system.

Wooly Apple Aphid infestation on branches

(III) Monitoring and surveillance

Visual inspection of infested trees is the best method for assessing the damage and monitoring the population numbers. Mostly the damage is more done by the immature insects as compared to adults (winged). Use of sticky traps is commonly used for monitoring the winged aphids. As this pest is known for upward and downward migration, it is better to wrap the sticky traps around the stem just above the ground level to observe the migration cycle of this pest.

(f) Tent Caterpillar

Scientific Name	:	*Malacosoma indicum* (Walker)
Family	:	Lasiocampidae
Order	:	Lepidoptera

(I) Distribution

It is distributed in north-western India and is the most serious pest in Himachal Pradesh and Jammu and Kashmir (Malik *et al.*, 1972)

(i) Detection and identification

Eggs: Eggs encircle the small branches and twigs in the form of rings with an adhesive substance secreted by the female. This adhesive substance is known as spumaline and forms a protective covering around the egg bands. Each egg band contains about 200-400 eggs. The egg stage lasts for about 9-10 months.

Larva: Caterpillar emergence from eggs starts in early spring at the time of bud break and more precisely when the leaves start emerging out. They start feeding on new leaves by forming small webs or tents, hence named as "Tent Caterpillar". The tents often found on the crotches of limbs act as a refuge for the larvae during the night. Caterpillars move out from the tents and feed on leaves. They feed in groups and cause heavy defoliation. Shredded skin of different larval instars can be found inside the tents and these webs/ tents can be easily seen.

Pupa: The pupal stage passes inside the cocoons. These cocoons are constructed loosely and are silky white in colour and oval in shape (Hill, 2008). The cocoons are present in the web and in dead tree material on the ground, or mostly inside of a rolled leaf.

Adult: The adults are brown and yellowish moths with two diagonal markings on the front wings. Only one generation is completed in a year.

Adult Tent caterpillar

Tents made by the Tent caterpillar

(II) Nature of infestation

Caterpillars rest at night in tents and feed during the day on leaves. The leaves are skeletonised leaving behind the midrib and veins.

(III) Monitoring and surveillance

The real estimate of overwintering population is to monitor the egg mass counts, as this insect overwinters in the egg stage. During early spring, the number of tents made by this pest is important to estimate the pest density as the caterpillar is the damaging stage. For estimating the adult population, pheromone-baited traps should be tied to the infested branches of the trees. The light traps are also effective in sudden outbreaks in the region, where tent caterpillar occurrence is most prevalent.

(g) Apple Stem Borer

Scientific Name	:	*Aeolesthes sarta* (Solsky)
Family	:	Cerambycidae
Order	:	Coleoptera

(I) Distribution

In India, it is widely distributed in Kashmir and Himachal Pradesh.

(i) Detection and identification

Egg: Eggs are laid on the dry woody portions of the host trees singly in the cuts and silts of the bark made by the female. A single female can lay about 100 eggs, which are creamy white and are elliptical in shape. Egg hatching lasts for 7-14 days.

Larva: Grubs are dirty white with a reddish-brown head. They start feeding by boring inside the stem. Grubs remain inactive during winter, start feeding in March and remain active for two years. They feed by boring the woody portion of stems and branches.

Pupa: Pupae are small, yellow-brown and sometimes pupal cases are observed in the trunk or on the infested branches. Pupation takes place inside a tunnel made in the woody tissue by the infested grubs. The pupal stage lasts for 40 to 100 days.

Adults: Adults are dark brown in colour with mottled yellowish pubescence on the elytra. Antennae of the male are 1.5 times longer than their body length, while females are of the same length.

Zig-zag galleries made by stem borer

(II) Nature of infestation

The newly emerged grubs feed on the bark and make zig-zag galleries. They bore and feed on sap wood (Beeson, 1941), throwing frass out from the exit hole. Sap flow is blocked or restricted by such feeding. The vitality of the tree is reduced leads to death of the plant. The infestation can be detected on the branches and main stem by visible exit holes with a diameter of 1 to 2 cm. Sap oozes out from these exit holes. When the grubs penetrate deep into the stem or branches, coarse saw dust comes out from these exit holes, which can be seen on the ground.

(III) Monitoring and surveillance

Monitoring the holes made by this pest is a sound method for estimating the intensity of damage. As no pheromone has been isolated from this species, visual inspection of trees is the only method for survey and surveillance programme. Larva bore inside the trunk and branches result into the excavation of dust coming out of the exit holes. In severe case, huge infestation shows the symptoms of rotting bark. Dying and dead limbs, and yellowing of leaves is a peculiar symptom, when the attack is severe.

(h) The Bark Beetle

Scientific Name : *Scolytus nitidus* (Schedl)

Family	:	Scolytidae
Order	:	Coleoptera

(I) Distribution

It is distributed in Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh. Dry and hot weather conditions increase its infestation level. It is a most serious pest in un-irrigated slops of Kashmir Valley especially in apple orchards.

(i) Detection and identification

Egg: The egg is slightly oval and pale white in colour. The eggs are covered by the boring dust. The female lays on an average 60 eggs, which hatch in 5 to 7 days.

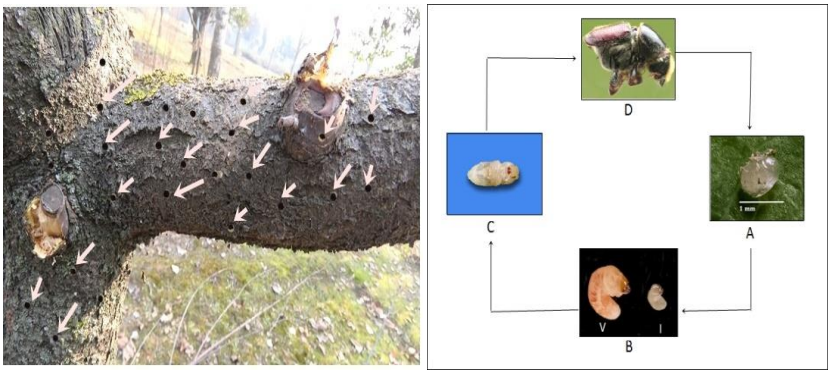
Grub: Newly emerged grubs look like minute immobile white dots. Immediately after feeding, the grub becomes light creamy in colour, curved and legless. The larval development is ranges from 38-50 days consisting of five larval instars.

Pupa: The pupation takes place in pupal cells at the ends of larval galleries. The pupa is soft and white. The pupal stage last for 6-18 days.

Adult: The cylindrical adult is 4.00 mm long and 1.68 mm wide (Buhroo and Lakatos, 2007). It has shining black pronotum and dark red brown elytra with declivous abdomen. The adults live for 45-60 days. This species undergoes two complete and a 3rd partial generations per year in Kashmir (Buhroo and Lakatos, 2007)

(II) Nature of infestation

The adult females of this pest cause damage by girdling a shot-hole in the inner bark (the phloem-cambial region) on twigs, branches or trunks of apple trees. This activity often results in falling of frass on the surface of soil. Small emergence holes in the bark are a good indication of the presence of bark beetles. Removal of the bark with the emergence holes often reveals dead and degraded inner bark. Galleries are found under the bark due to which the blocking of food and water is severely hindered. During the early part of the attack, the tree does not show symptoms, but growth is arrested. Infested trees show a reduction in foliage and fruit yield.



Emergence of bark beetle and Life stages of *Scolytus nitidus*.
A- Egg stage, B- Larval stage (I & V instars), C- Pupal stage, D- Adult stage

(III) Monitoring and surveillance

For adult monitoring, bark beetle should be monitored through pheromone baited traps. As the bark beetle infestation is not prevalent to all apple trees, because of the aggression pheromone. It has been seen that bark beetles are ethanol hungry and ethanol baited traps should be installed to monitor their population. Yellow sticky traps also work well for the monitoring of shot hole borers, when directly hung on the infested tree. Mostly healthy plants avoid attack by shot hole borers by the flow of sap at great pace from the wound sites. So weak trees should be monitored as these plants suspect infestation by shot hole borer and the most prominent damage could be seen on the tip regions of the branches of the host trees.

(i) Apple Leaf Miner

Scientific Name : *Lyonetia clerkella* Linn.

Family : Lyonetiidae

Order : Lepidoptera

(I) Distribution

In India, it has been reported in Jammu and Kashmir and the losses by this pest are prominent.

(i) Detection and identification

Egg: The egg looks like a small scar and eggs are laid inside the cuticle of the leaf.

Larva: The larva possesses chewing mouthparts and a prominent head capsule. The larva also contains six thoracic and abdominal legs**.** The larvae are green in colour and live and feed inside the leaves. The larva leaves the mine prior to pupation through an exit in the upper epidermis of the leaf.

Pupa: Pupa forms a silken cocoon attached with a leaf like that of a "hammock" passion on the upper side of a leaf. Pupa hangs on the leaf as a hammock, sometimes it folds the leaf.

Adult: The adult of the leaf miner is very small with shiny white wings and brownish markings on the tips of the wings. The invasion of this pest in Jammu and Kashmir has been studied by Rather and Buhroo (2015).

(II) Nature of infestation

Damage done by the leaf miner is only present on the leaves. The larva damages the leaf tissues and feeds between upper and lower epidermis. The whitish or brown long, narrow and sinus tunnel is mined by the larvae on the upper surface of leaf. The management guidelines are not available in Jammu and Kashmir, because the attack by this pest on apple orchards is not so serious**.**

Leaf miner infestation (Source: www.rhs.org.uk)

(3) Integrated pest management (IPM) for insect –pests in Kashmir Valley

S.No	Name of the Pest	IPM strategy
1.	**San Jose Scale**	❖ Pruning, collection and burning of infested branches and twigs to ensure complete orchard sanitation. These twigs harbor San Jose scales during winter. ❖ Application of dormant spray oils @ 2 % before leaf emergence or at late dormant stage of apple trees. ❖ Spraying of Chlorpyriphos 20 EC @ 1ml /l of Water ❖ Spraying of Dimethoate 30 EC or Quinalphos 25 EC @ 1ml /liter of water when emergence of crawlers has been noticed. ❖ *Encarsia perniciosi* and *Aphytis diaspidis (*Parasitoids of San Jose scale) are mass produced and mass released to check the San Jose Scale population. ❖ Mass production and mass release of predators (*Chilocorus* Sp.) to check the San Jose scale infestation on fruits and twigs.
2.	**European Red Mite (ERM)**	❖ Collection and burning of pruned twigs to reduce overwintered population as the egg laying is being noticed on these twigs by ERM. ❖ Application of winter spray oil @ 2 % at dormant stage of apple trees or summer spray oils (75 ml /10 liters of water) during summer to check both overwintering and summer eggs of ERM, respectively. ❖ Conservation, mass production and mass release of predatory mites (*Amblyseius fallacis*) and lady bird beetles should be done to check the population of ERM. ❖ Spraying of Fenzaquin 10 EC or Hexythiazox 5.45 EC @ 4 ml / 10 liters of water. ❖ Spraying of Fenpyroximate 5 SC and Propargite 57 EC @ 10 ml / liter of water
3.	**Codling Moth**	❖ Collection and destruction of fallen fruits to reduce the infestation/ population of codling moth in next season. ❖ Pruning is not practiced in Ladakh as the insecticidal film does not cover the apple tree completely. ❖ Burlapping of apple stems with gunny bags or cardboard material to trap the overwintered larvae of codling moth. ❖ Mass trapping of codling moth by use of pheromone baited traps reduce the infestation of codling moth. ❖ Application of insecticides like Chlorpyriphos 20 EC, Dimethoate 30 EC @ 10 ml / 10 liter of water before the larvae penetrate into the fruit significantly reduces the fruit damage. ❖ Releasing of egg parasitoids (*Trichogramma embryophagum* and *T. cacoeciaepallidum)* target the eggs of codling moth, significantly reduce the fruit infestation. The synchronization of egg laying by codling moth should coincide with the release of egg parasitoids for a very good control. ❖ The gadgets used for various IPM strategies should be made easily available in the Ladakh region.

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4.	**Indian Gypsy Moth**	❖ Survey and scouting for the removal and destruction of egg batches is enough for the management of this pest in well managed apple orchards. ❖ Application of Nuclear Polyhedrosis Virus (NPV) and spraying of Dimethoate 30 EC @ 1ml / liter of water if damage has been noticed in apple orchards. ❖ Monitoring the adult population by use of pheromone baited traps is very important for any pest management strategy.
5.	**Woolly Apple Aphid**	❖ Spraying Dimethoate 30 EC and Ethion 50 EC @ 10 ml / 10 liters of water. ❖ Some MM series root stocks has shown resistance against Wooly apple aphid. ❖ Conservation, mass production followed by mass release of exotic parasite, *Aphelinus mali* is very effective to check the population of woolly apple aphid. ❖ Conservation of predators should be ensured by minimizing the pesticide application to maintain the pest defender ratio balance.
6.	**Tent caterpillar**	❖ As this pest is reported from few pockets of Kashmir valley, the proper management strategy for this pest is not proper. It is a minor pest of apple. ❖ Go for scouting the egg bands of Tent caterpillar when regular monitoring of apple orchards is to be carried out. ❖ Application and use of NPV reduce the caterpillar damage on tree foliage. ❖ Use Dimethoate 30 EC @ 10 ml / 10 liters of water when insect outbreak is observed
7.	**Apple stem Borer**	❖ Monitor the attacked twigs and branches infested by stem borers, burn them in winter and scout the dry wood inside the orchards as the female beetles love to lay eggs on dry wood. ❖ Spraying of Chlorpyriphos 20 EC and Dimethoate 30 EC @ 10 ml/ 10 litres of water at the time of egg laying. ❖ Apply fumigant granules inside the live holes made by the grubs and then seal these holes in stems and branches of apple trees with adhesive tapes or mud or any material that blocks the passage of air. ❖ Pheromone trap could be a big achievement to trap adult population of apple stem borer. ❖ Mixing of paint with insecticides and then applying on tree trunks reduces the insect attack and infestation on tree trunks. ❖ The heavily infested limbs and trees are to be uprooted and burnt to slow / prevent the spread of the stem borer infestation and outbreak in un-infested orchards.
8.	**Bark beetle**	❖ Scouting and monitoring the infested trees and branches as the bark beetle attack in patches. ❖ Application of insecticides before the adults penetrate and lay eggs on the bark by using Chlorpyriphos 25 EC and Dimethoate 35 EC @ 10 ml / 10 liters of water. ❖ Heavily infested limbs and branches attacked by bark beetles should be removed and burnt. ❖ The trees with some sort of stress due to some unfavourable conditions for their proper growth are to be monitored more carefully as compared to healthy ones.

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		❖ Use of pheromone traps is effective way to trap adult population and timing of insecticide applications for the management of this pest.
9.	**Apple leaf miner**	❖ Monitoring and trapping of leaf miner by the use of pheromone baited traps. ❖ Application of systemic insecticides for the management of this pest when this pest attains an epidemic status.

Source: Spray Schedule. Directorate of Research, SKUAST-Kashmir.

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APPLE Production & Value Chain Analysis

The present book is a collection and synthesis of 30 lead papers contributed by R&D workers/experts/policy planners from different institutions/organizations as a part of their independent studies conducted at different times. It covers status, achievements and future R&D strategies on different issues concerning Indian Apple vis-a-vis global advancement. The issues covered range from research needs, innovative technologies, genetic resources, nursery management and crop improvement, disease and pest management, mechanization, pre- and post harvest management and economics, finance, marketing & trade. It is hoped that the book will be of interest and benefit the students, development workers, teachers, researchers, policy makers and farmers involved in apple cultivation.

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