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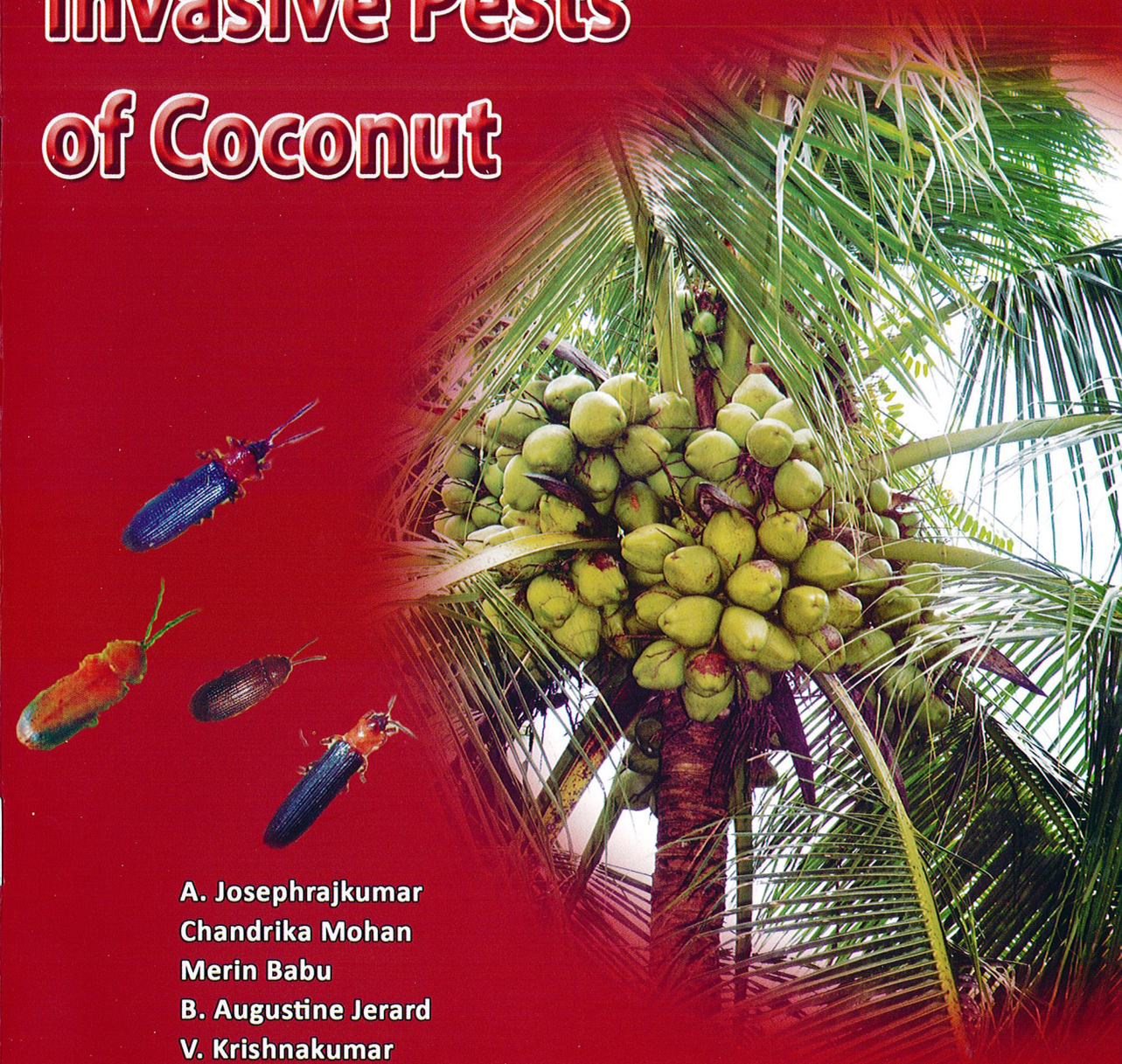
Invasive Pests of Coconut



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Centenary Publication-12

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CONTENTS

Biosecurity issues

The world is currently facing massive biodiversity loss due to human overpopulation, habitat destruction and fragmentation, climate change, the effects of invasive species, disease, pollution, excessive recreational use and harvesting, and natural ongoing geological processes. Biological invasions by non-native (exotic) species constitute one of the major threats to natural environment and biodiversity including forestry livestock and agro-ecosystem. Invasions by alien species imbalance native ecosystems and many of them cause considerable economic loss in the initial phase of entry. Such intruders are likely to breed profusely in the absence of natural enemies in the newly found environment and cause biotic upsets out-competing native species. The introduction of new pests into a locality is brought out in various ways such as 1) through a host as the carrier, 2) inert packing materials carrying the quiescent stages of the pest, 3) insect vectors, birds, and air currents and 4) deliberate, illegal introduction as bio-weapons. Though the first two modes of distribution are curtailed by quarantine measures, the latter two are beyond the limitations of pest control by exclusion. This creates a need for biosecurity involving integrated approach that encompasses the policy and regulatory frameworks to analyze and manage the risks in the sectors of food safety and other environmental risks.

Biosecurity covers a broad spectrum of issues ranging from the introduction of pests and diseases of plants and animals, genetically modified organisms and their products and management of invasive alien species and genotypes. As such, it is a holistic concept having direct relevance to the sustainability of agriculture, food safety and protection of the environment including biodiversity. The whole area of biosecurity is a very critical issue for international security. Biosecurity threat involving the fungus *Phytophthora infestans* in 1840 causing the great Irish potato famine is one classical example. Introduced crops may carry plant pathogens / pests or acquire them as a consequence of new encounter in the new environment.

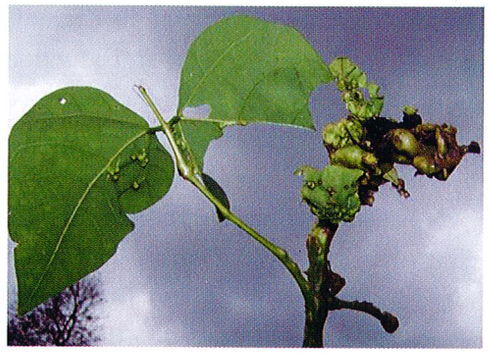
Biological invasions, the routine importation (both accidental and deliberate) of harmful non-native organisms occur daily, and are estimated to cost more than $100 billion per year world-wide. Nonetheless, the scientists, policy makers and public are paying considerably less attention and spending far fewer resources than needed to identify and address bio-invasions and their manifold impacts that include chronic damage to societal infrastructure, agro-ecology, fisheries, the environment and human health.

Economic losses due to bio-invasions are substantial in many parts of the world including India. Twenty-five per cent of costs of food accessible to customers are attributed to invasive weeds, pests and diseases. Invasive species are second only to habitat destruction as the major cause of biodiversity loss. In the globalized era, goods and services produced in one part of the world are increasingly available in other parts of world and people around the globe are more connected to each other than ever before paving way for accidental introduction of invasive pests. International travel has now become more frequent resulting in several biosecurity threats. Establishing risk-based biosecurity systems in different countries is vital to safeguard the food supply chain.

The Invasive Species Specialist Group (ISSG) is a global network of scientific and policy experts on invasive species, organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN). In recent years, major introductions have occurred on four crops: wheat, rice, maize and potatoes that constitute 50% of the world's food supply. Karnal bunt, *Tilletia indica*, an Asian fungal disease of wheat, was introduced into the US in 1996, where it is under containment in southwestern states. Potato late blight disease that led to the death or emigration of several millions of rural poor in the mid-1800s, continues to evolve and spread new virulent strains. In East Africa, wheat stem rust, *Puccinia graminis*, has recently re-emerged after decades of suppression with resistant varieties, creating a global biosecurity risk if it now spreads.

Invasive pests in India

Alien invasive species have invaded native biota in virtually every ecosystem of earth, causing economic damage to biodiversity and the valuable natural agricultural system we depend upon. Such outbreaks of exotic pests *viz*., coffee berry borer *Hypothenemus hampei* Ferrari (Curculionidae: Coleoptera), serpentine leaf miner *Liriomyza trifolii* (Burgess), (Agromyzidae : Diptera), spiralling whitefly *Aleurodicus dispersus* Russell (Aleurodidae : Hemiptera), coconut eriophyid mite *Aceria guerreronis* Keifer (Eriophyidae : Acari), erythrina gall wasp, *Quadrasticus erythrinae*



Gall wasp damage on *Erythrina* sp.

Rejuvenation of papaya after release of exotic parasitoid against mealy bug

Kim. (Eulophidae : Hymeonptera), the eucalyptus gall wasp *Leptocybe invasa* Fisher & La Salle (Eulophidae : Hymeonptera), cotton mealy bug *Phenacoccus solenopsis* (Tinsley) (Pseudococcidae : Hemiptera), the papaya mealy bug, *Paracoccus marginatus* Williams and Granara de Willink (Pseudococcidae : Hemiptera) and the tomato pin borer, *Tuta absoluta* Meyrick (Gelechiidae : Lepidoptera) reported in India caused severe economic loss to crops despite several efforts made to combat them. Biosecurity has wider implications since it relates to the livelihood security of nearly 70 per cent of the population, in addition to the food, health, trade security and natural resources of plants, animals and farms of the nation.

Coconut, *Cocos nucifera* L. popularly known as *Kalpavriksha* meaning 'Tree of life' or 'Tree of heaven" supports livelihood of about 12 million people in 18 States and 3 Union Territories in the country. It has been providing food, drinks, nutrition, health, shelter, income and wealth for mankind from time immemorial. As per latest coconut statistics from Coconut Development Board, the crop is cultivated in an area of 2.137 million ha in India with a total production of 22,680 million nuts and supports 12 million people for livelihood. Palm production faces serious challenges ranging from diseases to damage by insect pests, all of which may reduce productivity by as much as 30%. A total of 547 insects and mite species were reported as infesting coconut palm and copra in various coconut growing countries of the world. A few of the invasive pests like coconut eriophyid mite that had invaded coconut plantations of India in the recent past had caused tremendous setbacks in sustaining coconut production and revenue generation. A couple of them at our doorsteps are more dangerous in the offing.

Ecological threat due to biodiversity loss, economic upsets by invasion of alien invasive species, means to eradicate bio-invasion as well as minimizing associated risks are the daunting tasks ahead. Considering that almost 70% of the national population depends on agriculture, forestry, fisheries and animal husbandry for their health and livelihood, the need for agricultural biosecurity has been given

greater impetus at this point of time due to increases in the quantum of global trade and rapid transportation.

Invasive pests on coconut already reported in the country

a) Coconut eriophyid mite: The exotic pest, coconut eriophyid mite, *Aceria guerreroni*s Keifer was reported from all coconut growing regions ranging from 0.2% in Bay Islands to 57.3% in Karnataka. Ever since the pest was first reported in the country from Kochi, Kerala during 1998, it had spread like a wild fire affecting all coconut plantations in key south Indian states. Notwithstanding the higher mite incidence during the initial years of emergence (1999-2002), the percentage incidence of mite diminished in subsequent years (2010-2012) with the population buildup of natural enemies especially the predatory mite (*Neoseiulus baraki*) as well as the acaropathogen, *Hirsutella thompsonii* Fisher in the system.

The incidence of coconut eriophyid mite in various states and Union Territories (UT) is as follows

Distribution of mite incidence across the country

States/UT	Mite incidence (%)	
	1999-2002	2010-2012
Kerala	54.8	14.9
Tamil Nadu	55.8	34.5
Karnataka	57.3	43.2
Andhra Pradesh	24.6	34.7
Lakshadweep	3.6	20.5
Goa	3.5	9.5
Assam	Nil	21.9
Meghalaya	Nil	2.3
Andaman & Nicobar	Nil	0.2
Maharashtra	Nil	46.1

Coconut mite is a microscopic creamy white, vermiform organism measuring 200-250 microns in length and 36-52 microns in breadth. The body is

Microscopic view of coconut eriophyid mite

H. thompsonii infected mite

Neoseiulus baraki

elongated, cylindrical, finely ringed and bears two pairs of legs at the anterior end. An adult mite lays about 100-150 eggs. The eggs hatch into protonymphs, which further moult into deutronymphs and finally to adults. The total life cycle is completed in 7-10 days. Mite infests button during early stages of growth soon after pollination. Developing nuts harbour a large population of mite under their perianth. Symptoms appear approximately one month after initial colonization inside the pollinated buttons (female flowers) as white longitudinal patches or triangular yellow patches near the perianth. As nuts grow, these patches turn brown and longitudinal fissures and warts appear on the fruit surface. Drying, and shedding of buttons and young fruits are experienced in case of severe infestation. Dispersal of mites occurs through wind and population of mite reaches high during summer months from March to May.

The integrated pest management (IPM) strategy for suppression of *A. guerreronis* consists of phytosanitary measures in coconut plantations including crown cleaning, burning of fallen mite-infested nuts and plant protection operation by spraying/ root feeding of botanical pesticides (azadirachtin-based) thrice a year. In addition to this IPM package, adoption of integrated nutrient management package including application of NPK fertilizer as per recommended levels, recycling of biomass or raising and incorporation of green manure crops in coconut basins, summer irrigation

Progression of mite infestation

Mite damage symptoms on nuts

Spraying with botanicals

Cow pea in palm basin for biomass recycling

Talc-based preparation of *H. thompsonii*

and adoption of soil conservation measures were also recommended for the management of the pest. Three sprayings of palm oil (200 ml) and sulphur (5 g) emulsion along with 10 g soap powder in 800 ml of water on the terminal five pollinated coconut bunches during January-February, April-May and October-November evinced significant reduction (67.4 to 69.8%) of mite incidence. Application of talc-based preparation of *H. thompsonii* @20 g/litre of water / palm containing 1.6 x 10^8 cfu with a frequency of three sprayings per year resulted in 63-81% reduction in mite incidence.

Work done at ICAR-CPCRI revealed that palms of Chowghat Orange Dwarf (COD) showed minimum level of mite infestation in the field. Malayan Green Dwarf (MGD) and Spicata also recorded comparatively lower level of mite incidence, whereas, West Coast

Field view of Kalpa Haritha palms

Tall (WCT) and Laccadive Tall (LCT) recorded maximum incidence in the field. WCT with green and oblong nuts recorded higher level of mite incidence as compared to WCT with brown-colured and round-shaped nuts. The overlapping tepal aestivation and tepal tightness which make the entry of mites difficult at the early nut development phase are attributed to the lesser incidence of mite. Of late, a high-yielding, tall genotype recorded with lesser mite infestation at field level was selected at ICAR-CPCRI from Kulasekharam coconut population, christened as *Kalpa Haritha* and

Closer view of Kalpa Haritha

released for cultivation. Nation-wide sensitization and alert were exerted by all stakeholders and integrated approaches were used for the effective management of the pest.

b) Asian grey weevil: *Myllocerus undatus* Marshall (Curculionidae : Coleoptera), a pest of quarantine importance was registered from root (wilt) diseased tracts of coconut in Kerala. Mild to medium level of infestation damaging 5-10% of leaf area of un-split leaves with typical notching-like symptom along the leaf margins was noticed on majority of the coconut seedlings in root (wilt) endemic zones. In the nursery area with nearly 10,000 coconut seedlings, more than 40% seedlings were found infested by the weevil affecting the marketing potential of seedlings. The characteristic feature of this weevil is the presence of three-spined hind femur and is considered as an invasive pest from Sri Lanka. Adult weevil has a peculiar behaviour of dropping down (feigning death) under slight disturbances in order to escape from impending danger. Until this period, the insect was not reported as pest on any crop from India. Eggs are laid on soft organic matter on the ground and the grubs burrow through the soil feeding on the roots of the host plants before pupating in soil. Since the grubs are hidden in the soil, they are difficult to be detected and are thus vulnerable for spread to different regions through transport of coconut seedlings. The pest is likely to have more generations during warm equatorial type of weather conditions prevailing in Kerala triggering to the possibility of an outbreak situation. Currently, this species is known as an invasive pest in Florida occurring on most of the South-Eastern and South-Western coasts and scattered inland regions infesting at least 81 different plant species including three ornamental palm species *viz*., Burmese fishtail palm, *Caryota mitis* Lour., Golden cane palm, *Dypsis lutescens* (H. Wendl.) Beentje & J. Dransf. and Veitchia palm, *Veitchia* sp.. Very recently *M. undatus* is reported as a potentially destructive pest of citrus in Florida. Coconut ash weevil, *Myllocerus curvicornis* Fab. was also noticed on coconut leaves of young palms especially on outer whorls in different tracts of Kerala.

Leaf damage on adult palm and seedlings

Adult weevils of *M. undatus*

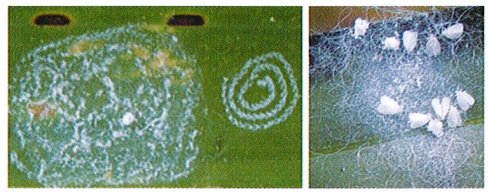
Three-spined hind femur

c) Inflorescence moth: Occurrence of non-native inflorescence moth, *Batrachedra arenosella* (*nuciferae*) was observed from Port Blair-Bay Island, Minicoy-Lakshadweep Island, Kasaragod-Kerala, Ambajipeta-Andhra Pradesh, Jagdalpur-Chhattisgarh and parts of Karnataka. The pest incidence was higher in Niu Leka Green Dwarf at World Coconut Germplasm Centre, Port Blair when compared to other Pacific Ocean collections maintained there. The incidence was reported in dwarf genotypes at Kasaragod, Kidu and in Lakshadweep Island whereas, all palms are seen infested at Raipur, Chhattisgarh. Gummy exudates on unopened spathes are amply visible and male flowers turn necrotic. Rarely infestation is also observed on buttons. The infested inflorescences exhibit the clinging of dried male flower parts over the spikelets making a dry appearance. Caterpillars are found to feed on the pollen grains of the male flowers. It is all likely that the pest could induce out-crossing in affected dwarf palms enhancing heterozygocity among the progenies. *B. arenosella* was reported as third important insect pest of coconut in

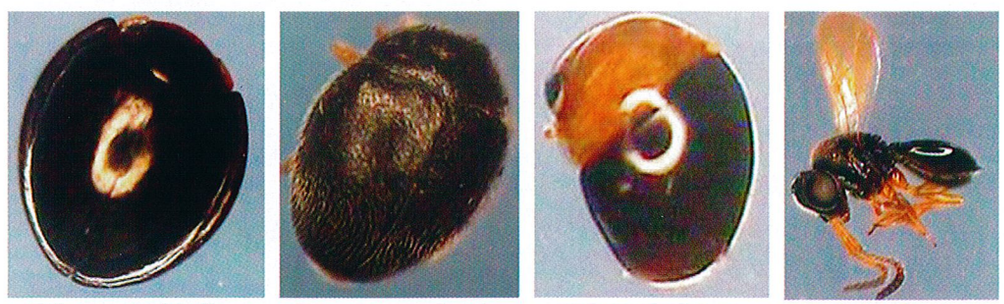
Damage symptoms and biology of *B. arenosella*

Indonesia. In 1998, *Batrachedra nuciferae* Hodges (Batrachedridae : Lepidoptera) was recorded from coconut in Venezuela.

d) Spiralling whitefly: Sporadic incidence of spiralling whitefly, *Aleurodicus dispersus* Russel recorded from Minicoy Island, Kerala and Tamil Nadu was effectively bio-suppressed by natural enemies. As the name suggests, adults of *A. dispersus* has a typical spiralling fashion of egg-laying and found in mild to moderate levels during March-May. It is a highly polyphagous pest infesting a wide array of crops in coconut plantations. Among the tall coconut types, Benaulim was found to be highly susceptible. In Minicoy, the spiralling whitefly nymphs were reported more on papaya, banana, tapioca and castor and were found parasitized by the aphelinid parasitoids. Adults measure about 2 mm length with white wings. Direct feeding even under heavy infestations is usually insufficient to kill palms and no significant yield loss is being reported. Indirect damage is mainly accomplished by the accumulation of honeydew and white, waxy flocculent material produced by the adult whiteflies. In addition to the accidentally introduced aphelinids, *viz.*, *Encarsia guadeloupae* Viggiani and *Encarsia* sp. nr. *haitiensis* Dozier, several natural enemies have expanded their host range to this invasive pest in India. At least two different species of lady beetles *viz.*, *Chilocorus subindicus* Booth (Coccinellidae : Coleoptera) and *Scymnomorphus* sp. (Coccinellidae: Coleoptera) were found predatory on spiralling whitefly as well as on coconut scale insects. Furthermore, a nitidulid predator *Cybocephalus* sp. (Nitidulidae : Coleoptera) identified by its hump-backed appearance is associated with bio-suppression of the



Damage symptoms of spiralling whitefly



Chilocorus subindicus | *Scymnomorphus* sp. | *Cybocephalus* sp. | *Encarsia* sp.

pest. Conservation of these lady beetles is therefore required for the natural suppression of the spiralling whitefly in Minicoy Island.

Impending biosecurity risks

Coconut leaf beetle, *Brontispa longissima* Gestro and the armoured scale insect, *Aspidiotus rigidus* Reyne ravaging Maldives and The Philippines, respectively though could not be encountered so far in our survey, are impending dangers at our door steps.

a) *Brontispa longissima* (Chrysomelidae : Coleoptera)

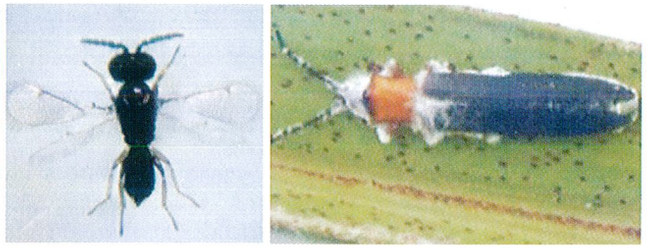
The outbreak of the *B. longissima* in Myanmar and Maldives in recent years poses a great threat and concern to the nearby countries such as India, Sri Lanka and Bangladesh. It is feared that the pest will find its way from Maldives to Sri Lanka and Southern parts of India to derail the economy of these important coconut growing regions of the world. Since invasive pests fail to restrict along political / agro-ecological boundaries, countries like India, Bangladesh and Sri Lanka are ever in red alert zones. For all those countries, where coconut and coconut-based industries support millions of people, the pest incursion would be catastrophic. Coconut leaf beetle (CLB) was originally described in 1885 from Aru Islands in Indonesia and from Papua New Guinea. Over a period of 130 years, it has widely spread in over 25 countries in Asia, Australia and Pacific Ocean Islands attacking a number of cultivated and wild ornamental palm species in addition to coconut palms. It is currently distributed in Australia (Darwin, Broome, Mao Island, Cooktown, Cairns, Innisfail, Marcoola and Townsville), Pacific Ocean Islands, Malaysia, Singapore, Cambodia, Laos, Thailand, Vietnam, Maldives, The Philippines, Myanmar and China. In Solomon Islands, it is estimated that about 5% of CLB infested palms die annually. In 1980, coconut palms grown in more than 10,000 ha area in seven provinces in Indonesia were attacked by this beetle. In Maldives, pest outbreaks occurred on several islands of South

Geo-map of *B. longissima* incidence

Damage symptoms

Adult beetle of *B. longissima*

Biology of CLB

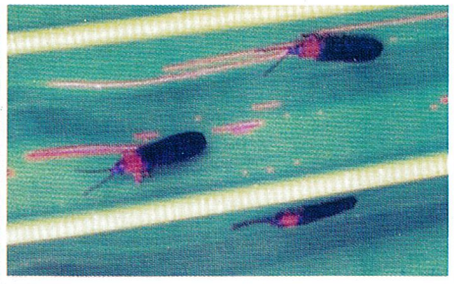


Natural enemies and entomopathogens invading CLB (*B. longissima* photo courtesy: APCC, Jakarta)

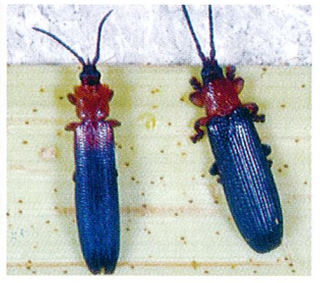
Ariatoll causing extensive damage to coconut production in inhabited and uninhabited islands. CLB had caused serious threats to the income generation from tourism industry as well as food security in countries like Maldives, Thailand and Vietnam.

Adult beetles measure 7.5-10.0 mm long and 1.5-2.0 mm wide, with a conspicuous orange to reddish pronotum. The anterior part of elytra is also orange to reddish in colour. Grubs and adult beetles inhabit the developing unopened still folded heart leaves of coconut palm and feed on leaf tissues. The spread of *B. longissima* is mainly through the movement of infested seedlings. Since the flight range of the beetles is low, the natural spread is at a very slow pace. Shipments of ornamental palms from countries having the pest infestation have been the main source of spread within the Asia-Pacific region. Pest management is mainly effected by release of biocontrol agents. Two parasitoids of coconut leaf beetle *viz.*, *Tetrastichus brontispae* Ferriere (Hymenoptera : Eulophidae), a pupal parasitoid and *Asecodes hispinarum* Boucek (Hymenoptera : Eulophidae), a larval parasitoid have been successfully used in several countries to control the beetle.

A close relative of *B. longissima*, *viz.*, *Plesispa reichei* Chapuis was reported from Sri Lanka. Belonging to the same family, *P. reichei* is reported only from the Island nation feeding on coconut



Feeding damage by *P. reichei*



B. longissima and *P. reichei*

leaflets and its pronotum is gradually narrower than *B. longissma*. Presently, the incidence is very sporadic and does not cause any economic damage as per reports from Sri Lanka.

b) *Wallacea* sp. (Chrysomelidae : Coleoptera)

Wallacea sp., a close relative of *B. longissima*, and feeding on the spindle region of coconut seedlings was recently recorded from South and Little Andaman. The feeding niche of *Wallacae* sp. confining on coconut spindle is a matter of concern, however, the pest was not observed from any adult palm during the snap survey conducted during October 2014. Though 80-90% of seedlings were infested by the pest damaging about 40% of leaf area, there was no seedling mortality. Invasive nature of *Wallacea* sp. is under scrutiny, as another chrysomelid beetle, *Wallaceana* sp. was reported from Indonesia. Adult beetles are brownish with six rows of constrictions on each elytron and measured 4.72 mm long and 0.9 mm wide. They are active fliers may be for a short distance. Grubs possessed short-lateral spines on each body segments with prominent mandibles for active feeding and measured 5.75 mm long and 0.8 mm wide. Grubs and adults remain within the folds of the spindle leaves and feed from within. Typical feeding damage

Damage symptoms on coconut seedlings

Grubs, pupae and adult beetle of *Wallacea* sp.

was seen within the leaf folds before unfurling along with faecal matters. In severe cases, the feeding streaks coalesce forming broader lesion with brown margin. Though a few feeding adult beetles were observed in between the leaf folds of emerged leaves, the grubs were mostly confined within the spindle region only. Pupae are located at the point of leaflet attachment to the main petiole. Pupae are exarate with exposed appendages and well-developed wing pads and are mostly located on the point of attachment of leaflet with the main petiole.

c) *Aspidiotus rigidus* (Diaspididae : Hemiptera)

Hard scale, *A. rigidus* is a close relative of *Aspidiotus destructor*. *A destructor* is a minor pest reported from Kerala, Tamil Nadu and other coconut growing tracts of the country. Gradient outbreak of coconut scale insect, *A. destructor* was observed at Chingoli near Kayamkulam, Kerala during August-September 2012. Though the pest attack was confined in a limited pocket on coconut leaflets along a homestead farm pond, rise in maximum temperature and reduction in relative humidity and rainfall during June-July 2012 could be the major reasons for the immediate flare up of the pest which was otherwise not reported as a major pest of the region. Population build up of the pest was so high that caused severe yellowing as well as drying of coconut leaflets in the region. This could be one of the earlier reports on temperature induced pest outbreak

Damage symptoms and biology of hard scale *Aspidiotus destructor*

Infestation of coconut by the hard scale *Aspidiotus rigidus* in The Philippines. (Photo courtesy: Royal Entomological Society)

from Kerala, India. Comparison of maximum temperature, relative humidity and rainfall data of June 2011 with that of June 2012 revealed increase in 0.8°C of maximum temperature and reduction in relative humidity and rainfall to the tune of 4.1% and 91.8 mm, respectively. Though *A. destructor* is under check by natural enemies, *A. rigidus* is reported to be a ravaging pest in The Philippines incurring huge loss to coconut growers in that country. It is also reported as an emerging invasive threat in our country. The mobile stage being the crawlers and males are easily drifted away by wind or passively carried through any inert packaging materials, nuts, leaflets, dried spathes, *etc.*

d) Red ring disease in coconut

It is caused by the nematode, *Bursaphelenchus cocophilus* (Cobb) Goodey and transmitted by the palm weevil, *Rhynchophorus palmarum*. Juvenile nematodes are transmitted especially during oviposition and other activities. Young palms between 2.5 and 10 years old are susceptible. Yellowing followed by browning and drying of older leaves and premature nut fall are the external symptoms noticed in affected palms. The cross sections of the affected palms show specifically the presence of a reddish-brown ring of 2-4 cm width located 2-5 cm inwards from the stem periphery as the characteristic diagnostic internal symptom of the disease. This extends throughout the

Cross section of trunk of red ring disease affected palm (Photo by R.M. Giblin-Davis, University of Florida)

Rhynchophorus palmarum (Photograph by Ulrich Zunke, University of Hamburg, Germany)

stem but is quite clear about 1 m above ground level. Red streaks may appear in the petioles, and the roots become orange to faint red, dry and flaky. The key diagnostic feature is the presence of the nematode in the reddened tissues. Gradually the affected palms die. It is distributed in Caribbean area (Grenada, St. Vincent and the Grenadines, and Trinidad & Tobago), Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama), North America (Mexico), South America (Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, and Venezuela).

Invasive diseases

1) Coconut foliar decay

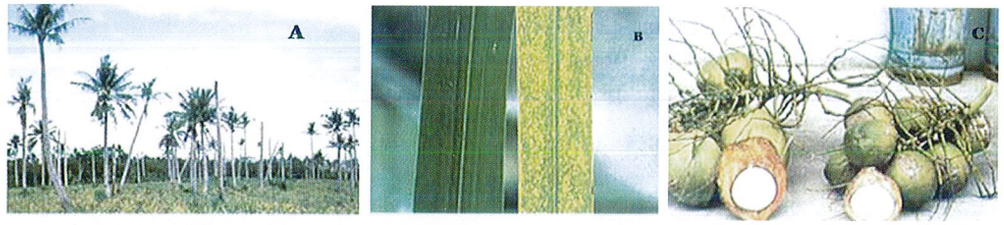
Coconut foliar decay disease is of limited distribution and has been detected only in coconut palms in Vanuatu. Yellowing of fronds in the middle whorls (about 7 to 11 positions down from the unopened spear leaf) is the initial symptom of the disease. Fronds that dry prematurely, hang down through the normal lower whorls of the crown. This is followed by yellowing and drying of other fronds in the crown. Susceptible cultivars like Malayan Red Dwarf die within 1 to 2 years after the appearance of the first symptoms. The disease is caused by an icosahedral coconut foliar decay *nanovirus* (CFDV) and is transmitted by the planthopper, *Myndus taffini* Bonfils

Symptoms of coconut foliar decay disease in Vanuatu (Photo courtesy : FAO/IBPGR technical guidelines for the safe movement of coconut germplasm)

(Cixiidae). No seed or mechanical transmission has been demonstrated.

2) Cadang-cadang

Cadang-cadang is a lethal disease of coconut prevalent in central Philippines. Coconut Cadang Cadang Viroid (CCCVd) belongs to the potato spindle tuber viroid subgroup. The earliest symptoms in naturally infected coconut palm are rounding of nut shape; the development of equatorial nut scarifications; and the appearance of fine, translucent, bright yellow leaf spots. Inflorescences become necrotic, nut production declines and then ceases. As disease advances, frond production slows and general chlorosis appears, followed by death of the crown. The affected palms die within



Symptoms of cadang-cadang disease: A- An area of high incidence of cadang-cadang disease in the Philippines B- Leaflets from healthy palm (left) and a palm with late stage disease showing non-necrotic chlorotic spotting (right).C- Nuts from healthy palm (left) and diseased palm showing rounding, equatorial scarifications and reduced husks (right). (Photo courtesy: Dr. John Randles, Waite Agricultural Research Institute, Glen Osmond)

eight to 16 years after the appearance of the initial symptoms. Variants of CCCVd occur in other members of the Arecaceae including oil palm (*EIaeis guineensis* Jacquin) and buri palm (*Corypha elata* Roxburgh.) and viroid-like sequences related to CCCVd have also been identified in a range of tropical monocotyledons in South-East Asia and Oceania. CCCVd has not been reported from India till date. In the field, natural transmission is observed but the mechanism remains as yet unknown. Pollen transmission is suspected.

3) Coconut tinangaja viroid

Coconut tinangaja viroid (CTiVd) is a single-stranded circular RNA with 254 nucleotides and about 64% nucleotide sequence homology to CCCVd. It is highly base-paired and stable. Symptoms include fine, yellow spots on leaves. Nuts of the affected palm may be scarified and round or more frequently, small and elongated and lacking a kernel. Diseased palms decline and die. It is distributed in Guam and means of transmission unknown.

Nut abnormalities associated with tinangaja disease (A) Scarifications and characteristic spindle shape (B) Sections of nuts from healthy and diseased palm showing lack of kernel development (Photo courtesy : G. Boccardo)

4) Coconut blast mollicute disease

Blast is a nursery disease reported from Africa. It is caused by a non- culturable mollicute. Disease appears as necrosis of

the basal tissues of the spear leaf which spread to the meristem and turning into a strong-smelling soft rot. When the seednut of the affected seedling is opened, a very strong putrid odour is detectable. Similar symptoms have been reported in oil palm and coconut in South America and in Indonesia. *Recilia mica* Kramer (Jassidae) is reported as the vector of blast disease. Since the disease is not associated with adult trees, there is no known risk associated with the movement of embryos and nuts.

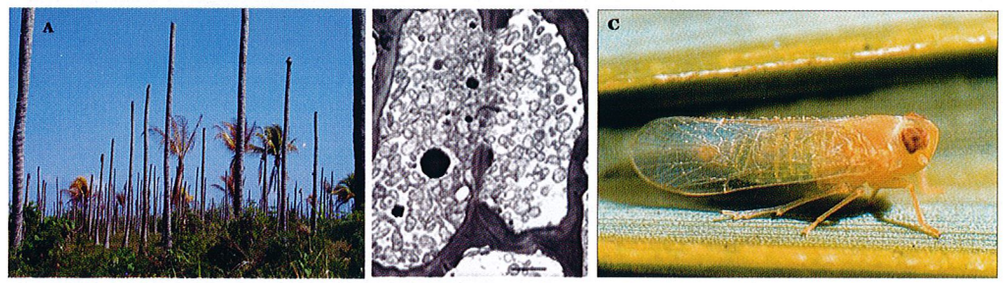
5) Lethal yellowing in coconut

Lethal yellowing is caused by *Candidatus* Phytoplasma palmae belonging to 16Sr IV group. Abnormal shedding of nuts of all ages accompanied by the appearance of one or more blackened newly-opened inflorescences are the characteristic initial symptoms of the disease. This is followed by yellowing and shedding of foliage which progresses upwards from the oldest fronds. A dry necrosis develops in the young, newly-expanding spear leaf which advances to the soft internal tissues above the growing point resulting in a wet, foul-smelling internal rot. The growing point may remain intact until most of the foliage is affected, but the crown eventually rots and falls off within 3-6 months of the appearance of the first symptoms.

The disease is prevalent in Bahamas, Cayman Islands, Cuba, Dominican Republic, Haiti, Jamaica, Mexico (Yucatan peninsula and Gulf coast) and USA (southern Florida, southern Texas). Diseases in Africa associated with non-cultivable mollicutes and similar to lethal yellowing are: Cape St. Paul Wilt (Ghana), Kaincope (Togo), Kribi (Cameroon) and lethal disease (Tanzania). In Florida, transmission of the disease by the planthopper, *Myndus crudus* van Duzee (Cixiidae), has been demonstrated.

6) Lethal bole rot

Lethal bole rot of young palms and seedlings is primarily caused by the fungus, *Marasmiellus cocophilus* Pegler.



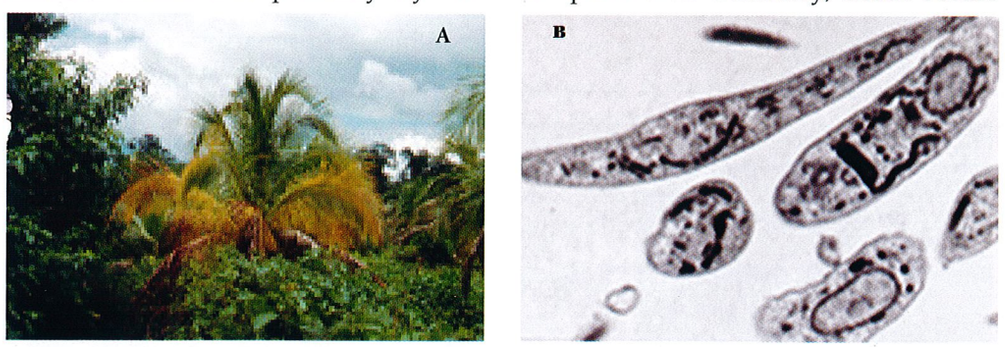
(A) LYD affected coconut palms (B) Electron micrograph of phytoplasma in phloem sieve elements of LYD affected palms (C) *Myndus crudus* (Photo courtesy : www.apsnet.org)

Sporophores of *Marasmiellus cocophilus* on a coconut seedling. (Photo reproduced from FAO/IBPGR technical guidelines for the safe movement of coconut germplasm)

Leaves wilt, become yellow and bronze. The spear leaf dies and a foul-smelling soft rot develops at the base of the leaves and spathes. On mature palms, leaves remain attached as a 'skirt' around the trunk. A reddish dry rot of bole along with decay of roots were observed in affected palms. *M. cocophilus* causes death in palms up to 8 years old. Spread occurs through soil, root contact between palms, infected coconut debris and probably by air-borne basidiospores. *M. cocophilus* has also been reported from several grasses, including *Eleusine indica* (L.) Gaertner, *Echinochloa colona* (L.) Link and *Cynodon dactylon* (L.) The disease occurs in Kenya, Tanzania and Solomon Islands.

7) Hart rot- a protozoan disease

The disease also known as fatal wilt/bronze-leaf wilt or Cedros-wilt or Marchitez is caused by plant trypanosomatids, *Phytomonas* sp. Yellowing or browning of the oldest leaves, starting from the tips and spreading to the base of the leaf is the prominent initial symptom of the disease. Yellowing progresses to younger leaves while older leaves become necrotic. Inflorescence necrosis and immature nut fall are also observed in affected palms. In the advanced stage of the disease, a rot develops beneath the spear leaf, extending into the apical meristematic region, and the palm dies. Generally, death occurs



(A) First stage symptoms of hart rot on coconut palm (B) *In vitro* cultured trypanosomatid isolated from coconut affected by hart rot in transmission electron microscopy (Photo courtesy: http://www.genoscope.cns.fr/spip/Plant-trypanosomatids.html)

within one month of appearance of external symptoms. It is reported from Brazil, Colombia, Costa Rica, Ecuador, Grenada, Guyana, French Guiana, Nicaragua, Peru, Surinam, Trinidad and Tobago, Venezuela. *Lincus croupius, L. tumidifrons* and *L. lethifer* (Heteroptera, Pentatomidae) are reported as vectors in South America. Other *Lincus* spp. are suspected vectors. In Brazil, another pentatomid, *Ochlerus* sp., is also suspected to be a vector.

SWOT analysis for *Brontispa longissima*

Critical SWOT analysis of biosecurity threat in the wake of accidental introduction of *B. longissima* in India is discussed hereunder. Consequent upon the absence of potential natural enemies of *B. longissima* in countries like India, an initial flare up of the pest similar to outbreak-like situation is imminent upon accidental introduction. Under the circumstances, the preparedness of handling such emergency-like outbreak situation through chalking our action plan for mitigating the disaster would be the key strategy.

Strength

Qualified and experienced technocrats are available in the country who had knobbed a similar introduction of invasive pests in plantation crops and other forest species. Subsequent setbacks upon introduction were managed extraordinarily well much to the appreciation of International communities. Importing exotic parasitoids, predators as well as entomopathogens in case of accidental introduction of alien invasive species through ICAR-National Bureau of Agricultural Insect Resources, Bengaluru is a routine procedure to thwart the threat quite comfortably. A planned emergency preparedness programme is in the offing to tackle the eventuality and subsequent disaster mitigation strategy. A well established quarantine system in vogue to strictly screen the ornamental palms imported from those countries with the prevalence of the invasive pest, *B. longissima*.

Weakness

Emergency preparedness strategies many a times could not match with swiftness in spread during accidental introduction of the invasive pest. Failures in domestic quarantine and, therefore, the spread internally, within the country would be catastrophic in different coconut growing tracts which assumes livelihood security to 12 million farmers. Knowledge about the invasive pest, *B. longissima* is presently inadequate among our scientific fraternities and hands on experience is lacking to face the threat.

Opportunities

Exchange of successful parasitoids from nearby countries whose innundative release could suppress the pest and promulgate knowledge sharing platforms to counter the spread.

Sensitizing and awareness campaign among the public about the impeding danger and counter defense mechanism to tackle the problem during accidental introduction. Periodical swapping of technical expertise from different countries who had managed the invasive pest in their country successfully.

Threat

An impending biosecurity threat when introduced affects the economy of the country. Coconut industry will be ruined in the initial phase of introduction if not handled meticulously.

Incursion management of invasive pests

Four pronged strategies are essentially warranted to keep vigil on the introduction of invasive pest.

(i) Strengthening quarantine:

Plant quarantine is a government endeavour enforced through legislative measures to regulate the introduction of planting materials, plant products, soil, living organisms *etc.*, in order to prevent inadvertent introduction of pests (including fungi, bacteria, viruses, nematodes, insects and weeds) harmful to agriculture of a country/state/ region, and if they are introduced, to prevent their establishment and further spread. After the Second World War, FAO convened an International Plant Protection Convention (IPPC) in 1951 to which India became a party in 1956. Currently it has 179 signatory countries. In Old Testament, the Book of Leviticus 13: 46, stated that anyone with leprosy remains unclean as long as they have the disease and that they must live outside the camp away from others indicating the influence of quarantine suppressing disease spread from time immemorial and its impact that is likely to bring forth benefits in the larger interest of the human well-being.

Strict quarantine laws curbing the movement of all types of coconut materials and other host palms particularly ornamental palms from CLB-infested countries should be enforced, as the main source of spread of this pest within the Asia-Pacific region is through shipment of ornamental palms from countries having the pest infestation. Shifting of soil and organic materials also should be passed through strict quarantine measures. In the collection of germplasm materials and exchange of genetic resources between countries rigourous quarantine steps are to be meticulously followed. Passengers traveling from beetle-infested countries should be encouraged to examine their baggage for the presence of the beetle / eggs / larvae to avoid accidental introduction of the pest. Trans-boundary movement of planting materials of palms especially ornamental palms between main lands and Islands as well between countries should be kept under strict vigil and generation of valid phytosanitary certificate. Quarantine officials need to be educated about the invasive pests and hitherto should focus on biological searches rather than bullion snatches. Both aerial and marine transshipment have to be covered under the umbrella of quarantine measures. Necessary phytosanitary certification by authorized agencies must be strictly enforced for the import of planting materials especially various palm species from pest-affected countries. Domestic quarantine should be further strengthened to keep away from *Wallacea* sp. reaching the mainland. Airports and seaports of Kolkatta, Chennai, Vishakapatnam and Cuttack should be strictly monitored.

The Directorate of Plant Protection, Quarantine and Storage (DPPQS) of Ministry of Agriculture and Farmer's Welfare is the nodal agency in India for implementing plant quarantine regulations which have recently been revised and known as the **Plant Quarantine (Regulation of Import into India) Order 2003 (henceforth referred to as PQ Order)**. DPPQS deals with the commercial import of consignments of grains, plants and plant products for consumption through its network of 35 Plant Quarantine Stations spread across the country including seaports, airports and land frontiers as well as commercial imports of seeds/ plants for sowing or planting through five major stations at Amritsar, Chennai, Kolkata, Mumbai and New Delhi. Besides the twenty-eight plant quarantine stations, there

Baggage check for effective quarantine

are seven stations *viz.*, Attari-Wagah Border- Railway Station, Attari-Wagah Border- LCS and Amritsar Railway Station (under RPQS Amritsar); ICD Tughlakabad, Air Cargo, Delhi Airport (under NPQS, Delhi), Air Cargo, Mumbai (under RPQS, Mumbai) and Air Cargo, Kolkata (under RPQS, Kolkata) as working units under the major stations. Pest risk analysis need to be undertaken in case of introduction of any organism into the country with sound scientific approach.

General recommendations that are to be strictly adhered in transfer of coconut germplasm

1) Preferential transfer through embryo culture or pollen and not as seed nuts.

2) Collection from absolutely healthy palms free of diseases especially those of unknown etiology in the immediate vicinity.

3) Seed nuts can be collected from area of no quarantine concern established through pest-risk assessment.

4) Seed nuts should never be moved from areas with non-culturable pathogens (phytoplasmas), *Phytomonas* etc.

5) Perfect disinfestation of seed nuts through fumigation with methyl bromide @ 32 g /m^3 for 3 h at 21°C.

6) Seed nuts are to be collected from a bunch with at least one nut turns drying colour.

7) Perfect indexing of virus and viroid diseases need to be followed before collection of pollen/embryos.

8) Transfer to be executed through perfect quarantine procedures and phytosanitary certificates by authorities concerned.

(Abstracted from Frison, E.A. and Putter, C.A.J. (eds.). 1993. *FAO/IBPGR Technical Guidelines for the Safe Movement of Coconut Germplasm.* International Board for Plant Genetic Resources, Rome.)

(ii) Pest risk analysis (PRA)

It is a systematic way of gathering, evaluating and recording information leading to recommendations for a position or action in response to an identified hazard (quarantine pest). It indicates the probability and the severity of impact of a particular pest of quarantine importance, likely to be associated with the commodity during its import. It also includes the possible phytosanitary measures to be taken by the exporting country to exterminate the quarantine pest from the commodity. It helps to ensure that decisions on the control of imports and exports are based on sound science-based process.

Why PRA?

PRA is done to protect the country's agriculture from damages that can be caused by harmful (quarantine) pests which can be brought in along with imported commodities. PRA evaluates the likelihood of the entry, establishment, or spread of a pest and the associated potential biological and economic consequences.

PRA process

It is a detailed study carried out by the importing country normally after official receipt of **Technical information** from the NPPO of the Exporting country. Technical information includes

1) Plant and plant product
2) Production area
3) Cultivation practices
4) Pest list
5) Packaging
6) Export program (Policy / Activity)
7) Copies of relevant documents

Three stages of PRA process

a) Initiation

In this stage, the pests and pathways of concern and the PRA area would have been identified. Relevant information will be collected and pests

will be identified as possible target for phytosanitary measures, either individually or in association with a pathway.

b) Pest risk assessment

This could be divided into three steps *viz.,* (a) Pest categorization, (b) Assessment of the probability of introduction and spread and (c) Assessment of potential economic consequences (including environmental impacts).

Pest categorization comprises of identification of quarantine pests, categorization of pests as well as preparation of data sheets of the pests. Quarantine pests are retained for further assessment. Risk assessment involves the probability of entry, establishment and spread of the pest. It involves the assessment of likelihood of establishment and spread potential of the pest after entry. Finally assessment of economic consequences such as impact on productivity, trade/ market access, environment and human health would be elaborately studied.

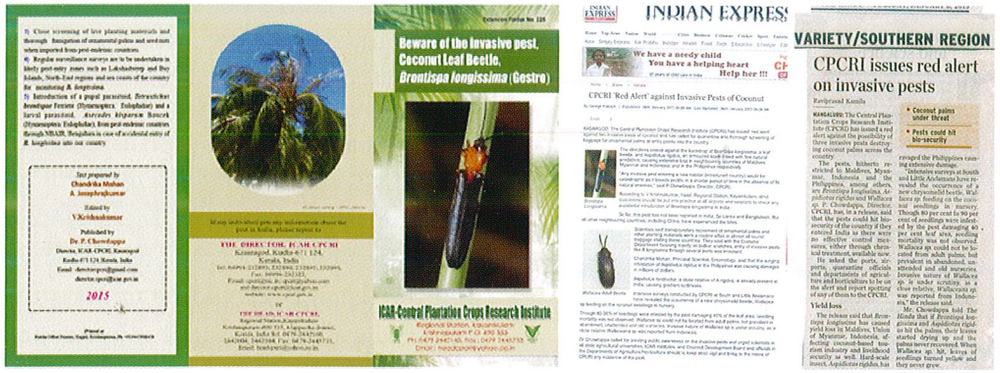
c) Pest risk management

The level of risk is to be identified along with required technical information. Appropriate risk management options need to be identified including phytosanitary certificates and other compliance measures. Risk management measures may be required to reduce the risk at an acceptable level.

(iii) Surveillance and monitoring

Regular surveillance surveys should be carried by all ICAR institutes, SAU and other stakeholders such as Coconut Development Board (CDB) at all strategic points of entry. More closely North-East regions, Lakshadweep and Bay Islands should be under strict surveillance by constant observation on buffer crops in those regions along the airport and seaport zones. With increasing navigation network these days, such surveillance surveys on regular mode is found mandatory. A national level incursion management team comprising of experts from all disciplines as well as an emergency preparedness module would be the need of the hour to tackle accidental introduction of invasive pests including gradient as well as epidemic outbreaks of emerging pests into the country. Concerted efforts for conservation of different natural enemies in the ecosystem are warranted for preventing emerging pests attaining epidemic levels.

Regular surveillance in strategic zones



Sensitization bulletins released from ICAR-CPCRI

(iv) Sensitization campaign

There is a need for educating the coconut growers and developmental workers about the pest and its bio-ecology so that they will be able to monitor the pest effectively in their areas of operation. Organizing seminars, awareness programmes, pest alert notifications, presentation of bulletins on *B. longissima* and *A. rigidus* are also would be helpful in building up an awareness and vigilance on the pest. Awareness creation and capacity building through training programmes is essential to contain the problem at this point of time. It was also suggested to display big posters at the lounges in airports and sea ports about the invasive pest and the damage symptom for the awareness of the travelers. Clippings can also be made about the invasive pests in Doordarshan news breaks. ICAR-CPCRI has been in the vigil since 2007 and in case if any report on the incidence of invasive pests are located anywhere in the country, the matter can be brought to the attention of us.

Way forward

Finally, a planned and holistic programme through awareness creation, capacity building on incursion management and strict quarantine are essentially warranted to combat invasions due to such biosecurity threats. Formation of an incursion management team with multidisciplinary experts is found crucial to tackle accidental introduction of invasive pests in to the country.

For further details and report about incidence of new pests, please contact

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