



# Indian Journal of Agriculture and Allied Sciences

A Refereed Research Journal

ISSN 2395-1109

e-ISSN 2455-9709

Volume: 4, No.: 1, Year: 2018

www.ijaas.org.in

Received: 15.03.2018, Accepted: 25.03.2018

Publication Date: 30<sup>th</sup> March 2018

## IMPACT OF INVASIVE INSECT PESTS SPECIES ON AGRO- ECOSYSTEM IN INDIA AND THEIR MANAGEMENT

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**Abstract:** The agricultural economy in India is vulnerable to threat from many potential bio weapons mainly invasive pests species. Invasive pest species are exotic, introduced, foreign, non-indigenous or non-native, is one that has been introduced by humans intentionally or otherwise through human agency or accidentally from one region to another. Invasive pest species have potential to rapidly established and spread in a new area cause major crop loss and can adversely affect food security. The spread of Invasive pest species is now recognized as one of the greatest threats to the biodiversity and economic well being of the country. The number of invasive insect pests species are introduce in India last 20<sup>th</sup> and 21<sup>st</sup> century by unintentionally or accidentally and they has greater impact on agriculture crop production as well as Indian economy. The introduction of new pest species in a new area minimized by the basic knowledge of invasive pest species with international cooperation through exchange of information on invasive pests and their natural enemies. There is a need for interdisciplinary coordinated work among scientists, in identifying invaded organisms and in assessing their ecological problems, environmental concerns in different ecosystems, economic damage and sustainable management by prevention, eradication and control.

**Keyword:** Invasive pest species, Biodiversity, Indian economy, Sustainable management.

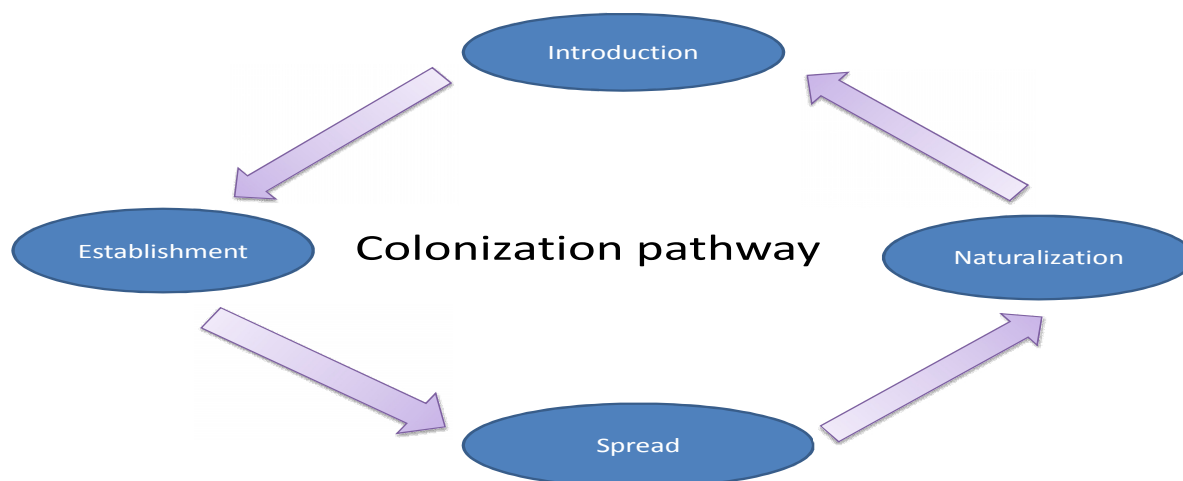
**Introduction:** An invasive pest species also known as exotic, introduced, non-indigenous or non-native, is one that is introduced by us from one geographic region to another intentionally or accidentally or through human agency for social or personal gain. Invasive pest species pose a serious threat to native biodiversity and after becoming locally dominant invade natural communities and are referred as Invasive Alien Species (IAS). IAS constitute the second most serious threat to biodiversity habitat destruction<sup>[1]</sup> and comprises the introduced plants, animals and organisms; the establishment and spread of which threatens ecosystems, habitats, and other species<sup>[2]</sup>. The globally worst more than 100 IAS include microorganisms, macro fungi, plants, invertebrates, amphibians, fishes, birds, reptiles, and mammals<sup>[3]</sup>. The global extent and rapid increase in IAS is homogenizing the world's flora and fauna<sup>[4]</sup> and such bio-invasion may be regarded as a form of biological pollution and significant component on global change and one of the major causes of species extinction<sup>[5]</sup>.

Agricultural trade and movement of seeds and planting materials has enhanced the risk of introduction of alien pests into India. These species, if not accompanied by the natural enemies which keep them in check in their native range, can multiply in large proportion and cause damage to economically important plant species and crop plants. He quoted instances of such invasion by the coconut eriophyid mite *Aceria guerreronis*, the cotton mealy bug *Phenacoccus solenopsis*, the papaya mealy bug *Paracoccus marginatus*, the eucalyptus gall wasp *Leptocybe invasa* and *Brontispa*, a beetle pest of coconut. In addition to the alien invasives from across political borders, invasion of pests can also occur from one geographic location to another within the same country<sup>[6]</sup>. The spread of Invasive Alien Species (IAS) is now recognized as one of the greatest threats to the ecological and economic well being of the country. These species are causing enormous damage to biodiversity and the valuable natural agricultural systems upon which we depend. Direct and

indirect health effects are increasingly becoming serious and the damage to nature and environment is often irreversible. The impact are exacerbated by global change and chemical and physical disturbance to species and ecosystems.

**Common Character and Colonization Process of Invasive Pests Species:** Invasive pest species have invaded and affected indigenous biota in virtually every ecosystem of the earth. Invasive species can transform the structure and species composition of ecosystems by repressing or excluding native species, either directly by out-competing them for resources or indirectly by

changing the way nutrients are cycled through the system. The environmental cost is the irretrievable loss of native species and ecosystem. There are following characters of invasive pests species describe [7]. Invasive species tended to have only a small subset of the presumed traits and that many similar traits were found in noninvasive species, requiring other explanations. Invasive species tended to have only a small subset of the presumed traits and that many similar traits were found in noninvasive species, requiring other explanation [8, 9, 10].



**Fig. Pathway of colonization**

#### Common Invasive Species Traits

- Fast growth.
- It very high and rapid reproduction even at unfavorable conditions.
- It more compatibility to survive with the alien ecosystem.
- Ability to move long distances.
- Phenotypic plasticity.
- Tolerance of a wide range of environmental conditions.
- It able to live off of a wide range of food types.
- Strong potential to compete with a native species.
- Association with humans.

**Impact of Invasive Pest Species on Agro Ecosystem:** The impact of invasive pests species is probably biggest threat to agro-ecosystem. Without natural enemies or control in the new land they take over the ecosystem and compete with native species. In the bargain, the native spp. could eventually be replaced by the non-

native which could not only severely alter, but may eventually take a whole ecosystem down. They can transform the structure and species composition of ecosystem by excluding native species by out competing them for resources or indirectly by changing the way nutrients are cycled through the system they cause negative impacts on, ecosystem, biodiversity, health, economics, other aspects of human welfare and decline agricultural yield. There are following species which is introduces in Indian and their impact on agro- ecosystem.

Woolly apple aphid, *Eriosoma lanigerum* (Hausmann) (Aphididae: Homoptera). It is native from China. During 1920 it reached a pest status in India [11]. Damage- caused by Adults and nymphs desap the plants. They also attack the roots which develop swellings (galls on roots), the whole plant look sickly and it may even die.

San Jose scale, *Quadraspidotus perniciosus* (Comstock) (Diaspididae:

Homoptera). It is native from China and introduced in 1911. The major host plants of the pest are apple, cherry, plum, pear, peach. In 1933 attained pest status in fruit orchards and plantations of poplars and willows. Infestation causes purple discoloration on the fruits. All surface parts of young hosts are infested. Attacks are generally on wood but, in severe infestations, leaves and fruits may also be penetrated. Heavy infestation causes cessation of growth and loss of yield.

Lantana bug, *Orthezia insignis* Browne (Orthezidae: Homoptera) introduced into India, Nilgiri region from Sri Lanka or West Indies. The major host plants of the pest are mainly lantana, Coffee, Jacaranda, Citrus, Sweet potato, Gumwood, Brinjal, Rose etc. It is a mobile scale insect, Adult female has a large wax ovisac and species is parthenogenetic. Eggs hatch inside the ovisac and the 1<sup>st</sup> instar nymphs then move out to feed.

Cottony cushion scale, *Icerya purchasi* Maskell (Margarodidae: Homoptera). It introduced in 1921. The major host plants of the pest are wattle tree *Acacia decurrens*, in addition to numerous other forestry and agricultural plant species. The scale has done serious damage to plants in the Nilgiri and Annamalai hills in South India and has become established throughout the country.

Potato tuber moth, *Phthorimaea operculella* (Zeller) (Lepidoptera : Gelechiidae). It is native- from Italy and introduced in India 1907<sup>[12]</sup>. It is a serious pest of stored potatoes, tobacco, tomato, brinjal, beet. Damage- Caterpillars initially mine into leaves and later make way in veins into petioles and then to stem and some time to the tubers in soil. In storage 30 to 70% tubers are damaged.

Diamond-back moth, *Plutella xylostella* (Linn.) (Plutellidae: Lepidoptera). It is native from European countries and introduced in 1941. Its polyphagous pest on cruciferous crops viz., cabbage, cauliflower, radish, knoll-khol, turnip, beetroot, mustard. Larvae mining and skeletonization of leaves.

Subabul psyllid, *Heteropsylla cubana* Crawford (Psyllidae: Homoptera). It is native from Central America and introduced in Chengalpattu district of Tamil Nadu, 1988 and Bangalore during May 1988<sup>[13]</sup>. Sucks the sap from young shoots, leaves and inflorescences which results in complete deformation of young shoots, plants. It is very serious pest in southern Indian states.

Serpentine leaf miner, *Liriomyza trifolii* (Burgess) (Agromyzidae : Diptera). It is native from USA (Florida) and first report of its occurrence in India appeared in the proceedings of the annual castor research workers' group meeting held at Hyderabad<sup>[14]</sup>. It is polyphagous pest (cucurbits, tomato, castor and ornamental plant)<sup>[15]</sup>. Damage-Larvae mine the leaf feeding on the mesophyll region of the leaves. Accelerate leaf drop thus exposing fruits like tomato. Vector of diseases. Reduction in crop yields. Aesthetic value of ornamental plants is reduced.

Coffee berry borer, *Hypothenemus hampei* (Ferrari) (Scolytidae : Coleoptera). It is native from Northeast Africa and first reported in India from Gudalur in the Nilgiris 1990<sup>[16]</sup>. Probably introduced accidentally either through coffee brought by refugees from Sri Lanka or through illegally imported coffee seeds<sup>[17]</sup>. Grubs burrow into stem for 8 to 9 months cause wilting of branches. The berries drop prematurely. 80% loss in yield. Prevalent in Tamil Nadu (Gudalur and Kilkotagiri), Kerala (Wyanad) & Karnataka (Kodagu).

Spiraling whitefly, *Aleurodicus dispersus* Russell (Aleyrodidae: Homoptera). It is native from Central America. First reported in Hawaii and introduced in 1994 in India<sup>[18]</sup>. It is highly polyphagous pest affecting wide range of host more than 481 plants. Nymphs and adults suck sap from host plants, Premature leaf drop. Honeydew is produced which serves as a substrate for dense growth of sooty mould interfering with photosynthesis. The adult population that builds up on avenue trees cause nuisance for people walking on roads under these trees during morning and evening hours<sup>[19]</sup>.

Coconut Eriophyid Mite, *Aceria guerreronis* Keifer (Eriophyidae: Acarina). It is native from Gururero in Mexico 1965 and introduced in Ernakulam (Kerala) and Pollachi (TN) 1998<sup>[20]</sup>. Present status of this pest is Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Lakshadweep Island. Damage- Suck the sap from tender meristematic tissues. Due to feeding warts and longitudinal fissures on the nut surface, discoloration of the nut and premature nut fall.

Silver leaf white fly, *Bemisia argentifolii* Bellows (Aleyrodidae : Homoptera). It is native from Greece and introduced a biotype B of *B. tabaci* was first noticed in October 1999 in Kolar district, Karnataka. The host plants of the pest are more than 900. This was associated with an outbreak of tomato leaf curl virus disease

(ToLCVD) which resulted in failure of tomato crop<sup>[21]</sup>. Damage-Piercing and sucking sap from the foliage of plants. Weakening and early wilting of the plant. Reduces the plant growth rate and yield. Leaf chlorosis, leaf withering, premature dropping of leaves.

Sugarcane Woolly Aphid, *Ceratovacuna lanigera* Zehntner (Aphididae : Homoptera). It is native from Java and first detected in West Bengal 1958. During 2002, outbreak was noticed in Maharashtra and Karnataka<sup>[22]</sup>. Both nymphs and adults suck the cell sap from lower surface of leaves. Sooty mould (*Capnodium* sp.) develops making the leaves look all black. Inhibits process of photosynthesis. In early growth period plants may die. Crop becomes stunted. Reduction in cane yield (25%) and sucrose content (26.71%). In Maharashtra (2003 to 2004) 267 thousand hectares of sugarcane were heavily infested by the aphid, with the districts of Sangli, Satara, Kolhapur and parts of Pune and Solapur. In Karnataka, (districts of Belgaum and Bidar) a total of 61 thousand hectares was affected during the same year. The pest has since then spread to Andhra Pradesh, Tamil Nadu and Kerala in the south, and Uttaranchal and Bihar in the north.

Erythrina Gall Wasp, *Quadrastichus erythrinae* Kim (Eulophidae : Hymenoptera). It is native- from Singapore and Mauritius and introduced in Thiruvananthapuram, Kerala, April 2005. Mode of entry-Through exchange of plant materials. The major symptom of the pest is gall-enlargement and malformation, wilting of leaves, Severe defoliation and Death of trees.

Papaya Mealy Bug, *Paracoccus marginatus* Williams & Graner de Willink (Pseudococcidae: Homoptera). It is native from Neotropical region (Mexico, Guatemala) and introduced in Coimbatore (Tamil Nadu) July 2008. The major host plant of the pest are papaya, guava, cassava, sweet potato, brinjal etc. (polyphagous). Leaves show crinkling. Leaves and fruits are covered with honey dew and sooty mould. Potential economic loss : 60 to 80 %. Present status- It has now spread to Kerala, Karnataka, Maharashtra and Tripura, presumably due to the movement of infested fruits<sup>[23]</sup>.

South American Tomato Leaf miner, *Tuta absoluta* Meyrick (Gelechiidae : Lepidoptera). It is native from Peru in South America and 1<sup>st</sup> reported in Pune, Maharashtra October 2014 by ICAR scientist. It has spread to tomato growing regions of Gujarat, Telangana, A.P., Karnataka, Tamil Nadu. The specimens were collected, identified and deposited in

National Pusa Collection (NPC), Division of Entomology, ICAR-IARI, New Delhi by ICAR-IARI scientists. Reported by K. Chandrashekar and P.R. Shashank<sup>[24]</sup>. The major host are tomato, potato, egg plant, tobacco, hot pepper etc. Feeding damage is caused by all the larval instars and throughout the whole plant. The larvae feeds on the mesophyll tissue, forming irregular leaf mines. Larvae also damage fruits by making pinhole symptoms and forming galleries. It can cause up to 90% loss of yield and fruit quality under greenhouses and field conditions. Present status- Subsequently the pest was observed in the farmer's fields in major tomato growing districts of Maharashtra viz., Pune, Ahmadnagar, Dhule, Jalgaon, Nashik, and Satara. It has recently been observed for the first time infesting tomato crop in research farm of ICAR-IIVR, Varanasi and farmers field of Varanasi and Mirzapur district during January 2017.

Rugose Spiraling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Aleyrodidae : Hemiptera). It is native from Miami-Dade county (South Florida) and introduced in September 2016, Pollachi, Coimbatore district, Tamil Nadu. Collected by Dr. K. Selvaraj Identified by Dr. R. Sundararaj<sup>[25]</sup>. At least 118 host plants included edible plants, ornamentals, palms, fruits and weeds of both native and non-native species. Damage-Cause on high yielding hybrid varieties of coconut. Infestation was very severe on lower leaves as compared to that of the middle and upper young leaves in dwarf and hybrid coconut palm which are about 4 to 6 years old. Population (immature stages) ranged from 18 to 37 nymphs/cm<sup>2</sup> of leaflet. Premature drying of leaflets. The continuous dry spell, availability of host plants in large area and absence of natural enemies might have favoured its multiplication. Present status-The current incidence of RSW in India is alarming due to its polyphagous nature. It has a great potential to extend its host range and spread to the coastal region of Kerala, Karnataka, Andhra Pradesh and Goa.

**Management of Invasive Pests Species:** CAB International for Global invasive species program (GISP) proposes three major management options, prevention, early detection, and eradication<sup>[26]</sup> for alien species management. A cost-effective option to prevent the introduction of alien species. Interception based on regulations along with inspections and fees, treatment of contaminated material, prohibition of commodities following international rules,

besides import risk assessment are the prevention options. Early detection focuses on a concern species. Species-specific surveys are designed and adapted for a specific situation considering the ecology of target species. Site-specific surveys can identify invaders near high-risk areas or in biodiversity rich areas. When prevention fails, eradication is the only option. Eradication aims to reduce the density of IAS below the acceptable threshold level.

**Strategies:** To knowledge the ecology and genetic make-up of the IAS is required for developing suitable management strategies.) The utility of genomic approaches for determining invasion mechanisms through analysis of gene expression, gene interactions and genomic rearrangements that are associated with invasion events <sup>[27]</sup>. The measures involving early detection with contingency plans for eradication/containment of invasive species can be efficiently implemented and would have a higher cost/ benefit outcome. In India, economic costs towards management of IAS are yet to be done in details. Three imperatives are evident at this juncture, namely: developing policies with sound biological rationales ensuring the effective biodiversity conservation affect; accelerating the implementation action on the ground urgently; and ensuring the legislative frameworks which are adequate to support the policies <sup>[28]</sup>. India maintains active coordination with FAO and with neighboring countries for surveillance, early detection and control measures for locust. Research and preventive control measures under way include study of the rodent characteristics, damage capacity, pathways associated with the pest and an environmentally friendly control strategy. The traditional knowledge of the local agrarian community of the region is also utilized. The management of invasive pest species by prevention of introduction in a new area, if the pest species are introduce in a new area and establishment than it manage by sustainable management of invasive pest species and eradication.

**Prevention by Legal Approaches of Pests Management:** A legal and institutional approach to the country's bio-security threat is a prerequisite to long-term success against invasive species. Unauthorized introduction of wild and domesticated animals and plants into new areas, between states and within the country should be reviewed and monitored by concerned Government departments. Techniques to be developed to make rapid assessment of the status

and movement of invaders and of their impacts on ecosystem. The Government of India has approved the notification of a new (Plant Quarantine Order, 2003) in harmonizing India's regulatory framework with the International plant protection convention and internationally accepted standards and the tenets of the SPS agreement of the World Trade Organization. Other supporting and managerial steps are also being taken to improve to international standards, the entire gamut of the country's quarantine activity and phyto-sanitary border controls, including import and export inspections, on-field surveillance for pests and vectors, treatment standards and processes, and certification methodology. Efforts are also continuing to improve the export certification process and standards <sup>[29]</sup>.

The 2003 new order for plant quarantine in India makes pest risk analysis a precondition for imports and prohibit import of commodities contaminated with weeds and/or alien species. Import of packaging untreated material of plant origin is restricted. A permit requirement is now enforced on imports of seeds, including flower seeds; propagating material and mushroom spawn cultures. Declarations are also specified in for the import of 144 agricultural commodities. There are now 130 of such entry points, whereby previously, it was only 59. The new order also rationalizes the structure of certification fees and inspection charges.

**Sustainable Management:** Some new initiatives in India may start to turn the tide against the invading plants. In the Himalayan and the Western Ghats regions of the country, ecologists from the Jawaharal Nehru University have been leading some promising projects which are developing landscape management plans with local communities. Identify the close parallelism between ecologically significant keystone species and the socially/ culturally/ religiously valued keystone species <sup>[30]</sup>. An approach based upon this connection enables local communities to identify themselves with a value system that they are able to understand and appreciate, and hence participate in rehabilitation activity that could check biological invasion. These community based approaches can best be complemented with technologies such as biological control, which can provide a long term sustainable component to an overall management plan.

**Eradication and Control:** Mechanical control is highly target- specific and labor-intensive.

Chemical control is often very effective as a short term solution. Classical biological control is highly cost-effective, permanent, self sustaining, ecologically safe and is appropriate for use in conservation areas, because of its environmental friendly nature and prohibition of pesticide use in such areas. Introducing a natural enemy (for example, water hyacinth weevil *Eochetina* spp. for *Eicchornia*) for eradication of invasive species is a current focus of interest. Control projects for invasive species offer a logical, long-term solution, but none has been seriously attempted in India. The support of all stakeholders must be ensured during the entire program<sup>[31]</sup>. Many exotic sawflies and wood wasps (Hymenoptera: Symphyta) have been reduced to insignificant pest status through introduction of parasitoids, or pathogens as shown from Canada<sup>[32]</sup>. Comparison of the pre-1960 faunal survey data for the Indian seas with that for the post-1960 period showed that 205 non-indigenous taxa were introduced in the post-1960 period. Shipping activity is considered as a plausible major vector for many introductions<sup>[33]</sup>. In India, plant protection is the joint responsibility of both the Central and State Governments. India has a multi-agency, multi-departmental, multidisciplinary, and multi-program approach for pest management, including management of IAS. There is no single national-level agency to coordinate management of IAS. India lacks a regional policy although it needs it at a regional and national level. An initial assessment, including a survey serves as a base for comparison as the program progresses<sup>[34]</sup>. All plants leaving and entering a nursery should be checked for sign of infestation<sup>[35]</sup>. In India, the bio-control agent (*Teleonemia scrupulosa*) released for *Lantana* control failed since it could not cope with the vigorous re-growth of *Lantana* at the onset of monsoon rains or the control agent itself suffered heavy mortality during winter<sup>[36]</sup>. Thus, the need for concerted research on suitable and environment-friendly control measures is clear. A set of strategic national plans and guidelines have been developed for the import of alien aquatic organisms to sustain the effort made for regulating the culture of alien species in the country<sup>[37]</sup>. Development of a national strategy should be the first step in managing IAS.

**Conclusion:** The invasive pest species has tremendous impact on the environment and agro ecosystem mainly agricultural production. These species are causing enormous damage to

biodiversity and these damage can also influence on the economic condition of the country. Direct and indirect health effects are increasingly becoming serious and the damage to nature and environment is often irreversible. The introduction of new pest species in a new area minimized by the basic knowledge of invasive pest species with international cooperation through exchange of information on invasive pests and their natural enemies. There is a need for interdisciplinary coordinated work among scientists, in identifying invaded organisms and in assessing their ecological problems, environmental concerns in different ecosystems, economic damage and methods of control. These interceptions, especially of pests and their variability not yet reported in India signify the importance of the quarantine in preventing the destruction of destructive exotic pests.

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