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REVIEW ARTICLE

Emerging insect pest problems in vegetable crops and their management in India: An appraisal

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ABSTRACT: In recent past, with changes in the cropping pattern, ecosystems and habitat, climate, and introduction of input intensive high yielding varieties/hybrids, a shift in pest status has been realized in time and space. Many pests have expanded their host horizon, developed resistance to pesticides and often there are secondary out breaks. Incidence of chilli gall midge (*Asphondylia capparis*) in parts of Tamil Nadu and Andhra Pradesh, solenopsis mealy bug (*Phenacoccus solenopsis*) in brinjal, tomato, okra and cucurbits; Hadda beetle (*Henosepilachna vigitioctopunctata* and *Epilachna dodecastigma*) on cowpea and bitter gourd; plume moth (*Sphenaeches caffer*) in bottle gourd are some of the examples. This paper envisages these emerging insect pests in vegetable ecosystem, their suitable control measures and some issues/challenges in their management.

Keywords: Emerging insect pests, management, vegetables

INTRODUCTION

Insect pests are the major biotic constraints to vegetables production in India. Apart from causing direct damage many of them also act as vectors for several viral diseases. The crop losses to the tune of 30-40 per cent have been reported in vegetable crops. Insect pests of much significance to vegetable crops and yield loss are given (Table 1). In recent years, with changes in the cropping systems and climate, and introduction of highly input intensive high yielding varieties/hybrids, a shift in pest status has been observed. Most of the plant protection recommendations in vegetables so far indicated the calendar based application of insecticides. This has become a common practice over the years by most of the farmers, growing vegetables in the country. Many pests have adapted new hosts, developed resistance to pesticide and often there are secondary out breaks.

Table 1. Yield losses due to major insect pests in vegetable crops in India

Crop/Pest	Yield loss (%)	Crop/Pest	Yield loss (%)
Tomato		**Cabbage**	
Fruit borer (*Helicoverpa armigera*)	24-73	Diamondback moth (*Plutella xylostella*)	17-99
Brinjal		Cabbage caterpillar (*Pieris brassicae*)	69
Fruit and shoot borer (*Leucinodes orbonalis*)	11-93	Cabbage leaf webber (*Crocidolomia binotalis*)	28-51
Chillies		Cabbage borer (*Hellula undalis*)	30-58
Thrips (*Scirtothrips dorsalis*)	12-90	**Cucurbits**	
Mites (*Polyphagotarsonemus latus*)	34	Fruit fly (*Bactrocera cucurbitae*)	
Okra		Bitter gourd	60-80
Fruit borer (*H. armigera*)	22	Cucumber	20-39
Leafhopper (*Amrasca biguttula biguttula*)	54-66	Ivy gourd	63
Whitefly (*Bemisia tabaci*)	54	Musk melon	76-100
Shoot and fruit borer (*Earias vittella*)	23-54	Snake gourd	63
		Sponge gourd	50

Source: Shivalingaswamy *et al*. (2002); Dhillon *et al*. (2005); Satpathy *et al*. (2005); Raju *et al*. (2007); Singh *et al*. (2007); Ghosal *et al*. (2012).

RECENT SHIFTS IN THE PEST SCENARIO

Some of the insect pests of vegetable crops become major and are gradually attaining the major pest status in different regions of the country due to changes in the ecosystem and habitats. *Helicoverpa armigera* in tomato, whitefly *Bemisia tabaci*, serpentine leaf miner *Liriomyza trifolii* on tomato and cucurbitaceous crops, fruit fly on fruits and vegetables, mealy bugs on several horticultural crops, gall midge on brinjal, okra stem fly and bitter gourd leafhopper, red spider mite on okra, brinjal, cowpea, Indian bean and nematodes on several vegetable crops are some of the examples. In recent times, there were outbreak of gall midge (*Asphondylia capparis*), which known to be a minor pest and gradually becoming a regular problem in chilli and capsicum and brinjal in the states of Andhra Pradesh and Karnataka and in brinjal in Chattisgarh. Various species of mealy bugs in cotton, vegetables and papaya have intensified their severity of occurrence in different parts of the country and have become indicator insects for the current ecosystems due to slow changes in climate in the last one decade. Several national and international polyphagus pests like termite, white grub, hairy caterpillar, gram pod borer and *Spodoptera litura* are also becoming severe and expanding their host-horizon.This envisages that there is a need to relook into the cropping systems for reorientation and vegetables should be given importance with adequate insect pest management measures. In this context, Integrated Pest Management (IPM) system was developed out of the need for sustainable crop protection strategy against the backdrop of increasing pesticide use and deleterious effect of residues in the environment.

Table 2. Changing pest scenario in vegetable crops in India

Insect Pest	Major host	Presently infesting	Reference
Serpentine leaf miner, *Liriomyza trifolii* (Burgress)	Tomato	Brinjal, Cow pea, French bean, Squash, Leafy vegetables, Cucurbits	Srinivasan *et al*. 1995
Spiraling whitefly, *Aleurodicus dispersus Russell*	Guava, Citrus, Tapioca	Bhendi, Capsicum, Brinjal, Tomato	Puri *et al*. 2000 Mani, 2010
Mealy bug, *Phenacoccus solenopsis* Tinsley	Cotton	Brinjal, Tomato, Chilli, Okra, Cucumber, Pumpkin	Chaudhary, 2006; Halder *et al*. 2013
Hadda beetle, *Henosepilachna vigintioctopunctata* Fab.	Brinjal	Bitter gourd, Cow pea	Rajapaske *et al*. 2005
Fruit borer, *Helicoverpa armigera* (Hubner)	Gram, Cotton, Tomato, Cabbage	Peas, Chilli, Brinjal, Okra	Puri *et al*. 2000
Gall midge, *Asphondylia capparis* Rubsaman.	Brinjal	Chilli, Capsicum	David, 2006; Nagaraju, 2000
Cabbage butterfly, *Pieris brassicae* Linn.	Cabbage, Cauliflower, Mustard	Knol Khol, Radish	Puri *et al*. 2000
Stem fly, *Ophiomyia phaseoli* (Tryon)	Beans	Okra	Patil & Jamadgni, 2008
Red spider mite, *Tetranychus urticae* Koch.	Okra, Brinjal	Cucumber, Cowpea, Indian bean	Mahto & Yadav., 2009
Leafhopper, *Empoasca motti* Singh-Pruthi		Bitter gourd	Puri *et al*. 2000
Plume moth, *Sphenarches caffer* Zeller	Field bean	Bottle gourd	Halder et al. 2014

Chilli gall midge

Gall midge, *Asphondylia capparis* Rubsaaman. (Cecidomyiidae: Diptera) is an emerging pest of chilli in parts of Tamil Nadu and Warangal district of Andhra Pradesh. The *A. capparis* is considered as major pest that causes paprika floral galls (Nagaraju, 2000) as the maggots feed on the ovary of the flower bud, flower and tender fruits. Infestation by the gall midge can easily be identified as the affected bud remains unopened, while the affected flower dries and drops, severe flower and fruit drops, reduction in yield, fruit size, seed number, production of malformed. The damage is more severe in areas where chilli is grown mostly under irrigated conditions. Maryana *et al.* (2006) observed flower buds or very young pods of chilli transformed into galls and opined that when young pods were attacked, they do not grow normally and remain smaller than normal pods. Sertkaya *et al.* (2006) noticed damaged fruits by *A. capsici* in the last week of July in both 2004 and 2005

and of the damaged fruits ranged from 1.41 to 69.71% in Antakya province of Turkey.

Management

Two hymenopteran parasitoids were recorded during the survey period on chilli gall midge *viz*., *Eurytoma* sp. (Eurytomidae), a larval-pupal parasitoid and *Bracon* sp. (Braconidae, a larval parasitoid). Highest parasitisation of 31.15% by *Eurytoma* sp. was observed in the month of November and the combined effect of *Eurytoma* sp. and *Bracon* sp. parasitoids ranged from 6.67- 24.58 with an average of 15.27 ± 6.69% in Karnataka (Basavraj *et al.* 2010). Tomar *et al.* 1996 from Madhya Pradesh reported that *Dinarmus* sp. (Hymenoptera: Pteromalidae) a new larval parasitoid of chilli gall midge, *Asphondylia capsici* Barnes.

Spotted pod borer

Spotted pod borer or *Maruca vitrata* Geyer (Pyralidae: Lepidoptera) previously considered as a minor pest of red gram and now become a serious problem in many vegetables like cow pea, field bean, cluster bean and pea. The damage due to this pest up to 42% in cow pea during rabi season in Andhra Pradesh (Halder and Srinivasan, 2011). This pest not only damage the pods of the plant but also feeds flower, buds and some time stem of the plants are infested (Halder *et al.* 2006; Halder and Srinivasan, 2007). The activity of *M. vitrata* observed almost all the states mainly southern, northern and central part of the country during rabi and pre-kharif season. Over lapping generations, short life cycle, wide host range and protective web forming nature of this pest are main reasons for its cosmopolitan distribution.

Management

Clean cultivation and removal of the web reduce the pest load from the field. Conservation of bioagents like *Apanteles sp* is effective. Need based spraying of azadirachtin @ 0.005 % or NSKE 4% or *Bacillus thuringiensis* var Kurstaki @ 1 kg/ha is recommended (Rai *et al*. 2014). For seed production, application of DDVP @ 0.75 ml/lit of water at flowering and early pod formation stage gives good control. Recently, Mittal and Ujagir, 2005 reported that Spinosad 90 g ai/ha was found to be effective against pod borer complex of pigeon pea including *M. vitrata*.

Hadda beetle

Hadda beetle or *Henosepilachna vigitioctopunctata* Fab. and *Epilachna dodecastigma* (Wied.) (Curculionidae: Coleoptera) is a well-known pest of eggplant and potato. But recently, its serious incidence was reported in cowpea as foliage feeder in many parts of the country particularly eastern Uttar Pradesh and Bihar. More than 80% leaves were infested by the grubs and adults of this beetle on cowpea during summer season (Halder *et al*. 2011). Similarly, its serious incidence was also observed from bitter gourd, *Momordica charantia* in Jammu (Jamwal *et al*. 2013), Allahabad in Uttar Pradesh (Maurice and Ramteke, 2012) wild bitter gourd, *Momordica dioica* in Maharastra (Deshmukh *et al*. 2012) and Ivy gourd, *Coccinia grandis* (Maurice and Ramteke, 2012) in Allahabad.

Management

Conservation of larval-pupal endoparasitoid, *Pediobius foveolatus* (Eulophidae: Hymenoptera) which cause up to 36.6% reduction in beetle population in and around Varanasi, Uttar Pradesh (Halder *et al*. 2011). Islam *et al*. (2011) observed that crude aqueous extracts of leaves *Ricinus communis* had highest larvicidal toxicity (LC_{50}=18.40%) besides significant reduction in both oviposition and egg-hatch, prolonged larval duration ($P<0.001$), and inhibited pupae formation and adult emergence. Amongst the entomopathogenic fungi, under laboratory conditions black muscardine fungi *Metarhizium anisopliae* @ 5 g/l gave good control (Annonymous, 2014). In another study, Vishwakarma *et al*. (2011) documented that, significantly maximum reduction in the population of *Epilachna* beetle (74.91%) was achieved in treatment of *Beauveria bassiana*, when used @ 3.0 g/l of water. Need based application of malathion or carbaryl @ 1 kg a.i. /ha or cypermethrin @ 0.4 ml/l is able to control this polyphagous pest (Rai *et al.* 2014).

Solenopsis mealy bug

Polyphagous, soft bodied this Solenopsis Mealy bug, *Phenacoccus solenopsis* Tinsley (Pseudococcidae: Homoptera) previously known as a pest of cotton but now possess a new threat to most of the cultivated crop plants. Out of a total record of 84 host plants across 28 families recorded at Central cotton growing zone of India up to 2009, 60 plant species from 22 families belonged to weeds (Vennila *et al*. 2010). Presently, they feed the host plants covering cereals, pulses, oil seeds, fruits, vegetables, ornamental crops as well as many weeds including *Parthenium*. Amongst vegetable crops, they found to attack on variety of plants belonging to malvaceae (ladies finger), solanaceae (tomato, brinjal, potato, chilly), leguminoceae (filed bean), cucurbitaceae (pointed gourd, cucumber, melons and gourds) (Halder

et al. 2013). Besides sucking the sap, they also secret the copious amounts of honey dew which deposited on the plants and create black sooty mould and there by reducing the photosynthetic activity of the plants.

Management

Removal of alternate hosts and weeds like *Parthenium*, *Vernonia* from the field will help to reduce the pest incidence. Ants also help in transmitting the mealy bug beside give protection to mealy bugs against its natural enemies. So, destruction of the ants' colonies during land preparation is advisable. Uprooting and burning the affected plants reduce the pests load from the field. Spraying of fish oil resin soap (FORS) @ 20 g/lit of water (Kumar *et al*. 2011) or entomopathogenic fungi *Verticillium lecanii* (2 x 10^8 cfu/ml) @ 5 g/lit of water give better control (Halder *et al*. 2013). In case of severe infestation spraying of Buprofezin 25% SC @ 1 ml/l or Acephate 75 SP @ 1gm/l or Malathion 50 EC @ 2ml/l of water is recommended (Rai *et al*. 2014). In another study Arif *et al*. 2008 documented that profenofos is the best insecticides against mealy bug causing maximum mortality after 24 hours. Recently, Patel *et al*. 2010 also reported that Buprofezin @ 625 g ai/ha is effective in controlling this pest.

Serpentine leaf miner

The American serpentine leaf miner, *Liriomyza trifolii* Burgess (Agromyzidae : Lepidoptera) which is a native of Southern United States of America and Central America has spread to other countries in seventies along with Chrysanthemum flowers (Puri and Mote, 2003). It is suspected that this species has entered in Karnataka along with plant materials during 1990-91 (Viraktamath *et al*. 1993) and then spread in many other parts of the country like Andhra Pradesh, Maharastra, Gujarat, Tamil Nadu, Uttar Pradesh, West Bengal, Delhi, Haryana and Madhya Pradesh. Srinivasan *et al*. (1995) reported 78 host plants covering pulses, fibre, vegetables, ornamental and flowers, green manuring, fodder crops, narcotics and weeds belonging to 16 families. In vegetables, three species of this pest reported and they found in infesting tomato, French bean, cow pea, cluster bean, summer squash, cucumber, melons etc. The losses to the extent of 15-70 % in French bean, 41% in cucumber and 35% in tomato have been reported by Krishna Kumar (1998) from Karnataka.

Management

It has been observed that higher dose of nitrogen favours the population buildup of this pest. There by judicious application of nitrogenous fertilizer reduces pest build up in endemic areas. Periodically infested leaves should be removed and destroyed. The pest can also be managed by using yellow sticky traps in the field for monitoring the presence (Lopez, 2010) and mass trapping of adults and exploiting the natural enemies. Recently, a new parasitoid *Neochrysocharis farmosa* (Eulophidae: Hymenoptera) has been reported from this leaf miner. During February-March, the per cent parasitization was 37.5 at Varanasi region, Uttar Pradesh, India. In Hawai, Gyaana and Senegal this pest was controlled by inundative release of parasitoids *viz*., *Hemiptarsenus*, *Chrysocaris* and *Chrysonomyia* sp. (Puri and Mote, 2004). In another study, it was also revealed that marigold (*Tagetes erecta*) plant serve as an attractant for this leaf miner besides it also attract large number of parasitoid *N. farmosa* (Anonymous, 2007). Application of NSKE 4% with a sticker found to be effective to deter the leaf miner. In case of severe infestation, spraying of Imidacloprid 17.8SL @ 0.3 ml/l of water during early stages of crop growth before flowering is effective (Nadagouda *et al*. 2010). Kumar *et al*. 2010 reported that soil application of phorate 10G @1 kg a.i./ha or seed treatment with Imidacloprid 70WS @ 3g/kg seeds or foliar applications of neem seed extract (NSKE) 5% on 10 days after germination gives better result in controlling the serpentine leaf miner. Rai *et al*. (2014) reported that spraying of imidacloprid 17.8 SL @ 0.35 ml/l of water during the early stage of the crops before flowering and application of dichlorovos 76EC @ 0.5 ml/l of water in severe infestation during reproductive phase crop is beneficial.

Phytophagous Mites

The predominant phytophagous mite species associated with vegetables are *Tetranychus neocaledonicus* Andre, *T. urticae* Koch., *T. cinnabarinus* (Boisduval) (Tetranychidae: Acarina) and *Polyphagotarsonemus* latus (Banks) (Tarsonemidae: Acarina). *T. urticae* Koch also called as two spotted mite or red spider mite is one of the most common and destructive species of mite which is cosmopolitan in distribution and is highly polyphagous in nature. It commonly associated with plants like ladies finger, brinjal, beans, cow pea and cucurbits (Singh, 2004). *T. cinnabarinus* though mainly feeds on cucurbits like pointed gourd, cucumber, melons, gourds but also found on a number of other crops including brinjal, beans, onion, peas, cole crops, tomato, sweet potato and various ornamental crops (Butani, 1984). The activity of these tetranychid mites has been observed during the post-monsoon period and dry period. The activity declines with the drop of temperature (Puri and Mote,

2004). *Polyphagotarsonemus latus* or yellow mite has also been identified as serious pest on chilli and beans. Due to infestation of this mite in chilli the underside of the leaves turns reddish and plants become rossetted. The '*Murda'* disease of chilli is due to infestation of this mite. During recent years major bottle neck of chilli growers in Varanasi region, Uttar Pradesh is heavy infestation of this mite which needs immediate attention (Singh, 2004). Nicotina and Cioffi (2000) referred to the dangerous diffusion of this broad mite on vegetables and floral crops especially in green houses. At cellular level, the typical symptoms of mite can be recognized by thickening the lower epidermal cells, elongation of the palisade cell layer, shrinkage and deformation of parenchymatous tissues (Rai *et al*. 2007).

Management

Spraying of chemical acaricides like dicofol 18.5% EC@ 2-2.5 ml/l or fenazaquin 10% EC @ 2.5 ml/l is able to control the pest. During initial stage of broad mite infestation destruction of severely attacked plant part mechanically reduces mite population. Conservation and release of native predatory mites if available also can minimize the mite populations from the field. *Amblyseius* sp. is an efficient predatory mite, which regulates the pest under field conditions. Botanicals like *Kochea* and *Calotropis* leaf extract showed strong acaricidal action under field conditions (Rai et al. 2014). In case of severe infestation, spraying of dicofol @ 2.5 ml/lit or propargite @ 3 ml/lit (Singh and Singh, 2004) or Fenazaquin @ 1.5 ml or spiromesifen @ 0.75 ml/l or chlorfenapyr @ 1.25 ml/l of water should be done at 10 days interval at the initiation of symptoms. Recently, Rai et al. (2014) described that integrated module comprising seedling dip with imidacloprid @1 ml/ lit, spray of buprofezin 1 ml/ lit at 25 days after transplanting (DAT), fipronil @ 0.2 g/lit at 35 DAT, *Verticillium lecanii* @ 5 g/lit at 45 DAT, chlorfenapyr @ 1 ml/lit at 55 DAT, Neem oil @ 1% at 65 DAT gave yellow mite reduction over control in chilli was highest in both Kashi Anmol (75.48%) and Kashi Gaurav (72.90%).

Plume moth

White plume moth, *Sphenarches caffer* (Zeller) (Pterophoridae: Lepidoptera), is a serious pest of lablab, beans etc. (Nair, 1995, Sujithra *et al*. 2010). Recently, it attained its pest status as a foliage feeder in bottle gourd as they damaged the leaves and buds of bottle gourd by scrapping the leaf portion thereby reducing the photosynthetic activity of the plants in and around Varanasi region. However, damage is more severe when they feed on the emerging buds resulting in restricted growth of the buds with characteristic black excreta inside it (Halder *et al*. 2014). During the peak summer months of May – June when atmospheric temperature was around 45°C in Varanasi its incidence was also observed and from mid-October onwards when rabi season bottle gourd was in its vegetative stage there was no incidence of this plume moth. Sujithra *et al.* (2010) from Tirupati, Andhra Pradesh reported *S. caffer* as a major pod borer of field bean. However, in Varanasi region incidence of this plume moth is restricted to bottle gourd.

Management

Conservation of solitary, larval, endoparasitoid *Apanteles paludicole* Cameron, 1909 (Braconidae: Hymenoptera) (maximum parasitization 40.91%) (Halder *et al*. 2014) and chalcid pupal parasitoid, *Tropimeris monodon* are beneficial. Need based application of *Bacillus thuringiensis* @ 1 kg/ha or malathion @ 2 ml/lit is able to control this pest.

Fruit flies

It has been estimated that in India, fruit flies alone cause losses up to Rs. 26,902 million when control measures were not provided (Stonehouse, 2001) and in addition 35 to 40% losses in gourds. Kapoor and Agarwal (1980) and Kapoor (1993) reported 159 host plants of various species of fruit flies from India. Among these, *Bactrocera dorsalis* (Hendel), *B. cucurbitae* (Coquillett, 1849), *B. zonata* (Saunders) (Tephritidae: Diptera) were recorded on different vegetable crops. If uncontrolled, these pests pose a serious limiting factor in the production of gourds, cucumber, melon and other cucurbits to the extent that it's growing may become highly unprofitable (Waseem *et al.* 2009). Beside these, this pest is very important in export point of view. Therefore, successive cultivation and export are highly relying on sound pest management system.

Management

Infected and damage fruits are often serve as source of infestation. So periodically all the infested fruits should be collected and destroyed. Earthing up of the soil around the vine helps in exposing the pupae for desiccation and predation by predatory birds. Ploughing the infested field after the crop is harvested can help in killing the pupae. Apply the bait spray containing 20 ml Malathion 50 EC + 10 g protein hydrolysate + 500g of molasses/jaggery in 20 litres of water per acre. When the attack is serious, it should be repeated at weekly intervals. Bait annihilation techniques with spray fluid with protein hydrolysate (0.3%) and malathion (0.015%)

followed by male annihilation technique (MAT) by adult flies through plastic bottle trap with ethanol, any insecticide (Carbaryl/Malathion), Cuelure (6:1:2) coated in wooden block. Installation of such traps @ 25-30 traps/ha is recommended (Rai *et al*. 2014).

Whiteflies

Amongst 1200 species of whiteflies, *Bemisia tabaci* (Gennadius) (Aleyrodidae: Hemiptera) is considered as the most important one. It is a cosmopolitan, highly polyphagous with remarkable ability to adapt to new hosts (Gerling and Kravchenko, 1995). It has been reported to attack more than 600 host plant species (Secker *et al*. 1998) belonging to 77 families (Basu, 1995). The economic damage may result from direct feeding leading to de-vitalization of the plants, yellowing and finally death of the plant. Beside these, they also secrets honey dew which creates sooty mould and there by restricting the photosynthetic activity of the plant. They also serve as vector for many dreaded viral diseases. Earlier this pest was considered as a minor pest and they were found to attack ladies finger, brinjal, chillies, cow pea, field bean, tomato, cucumber etc. and cause havoc loss both field and green house conditions. In recent years, severe incidence of leaf curl virus and yellow vein mosaic disease transmitted and spread by whitefly, has evoked wide spread concern in northern India. Similarly, the detection of Biotype-B of this pest in Karnataka on tomato causing severe incidence of leaf curl has sent a scare among the tomato growers in the country. Efforts are, however, on to evolve suitable management strategy for B-Biotype of whitefly as a pest and vector is the need of the hour (Puri and Mote, 2004).

Management

Yellow sticky trap to monitor this pest at early stage is recommended. Many weed plants harbor whiteflies, removal of weed hosts found to reduce both the incidence of whiteflies and associated viral diseases. Conservation of natural enemies like *Encarsia brevivena, Eretmocerus corni, Eretmocerus mundus* are some of the parasitoids, *Chrysoperla zastrowi sillemi, Mallada boninensis, Coccinella septempunctata* are the predators and *Beauveria bassiana* and *Paecilomyces farinosus* are the entomopathogens recorded from *B. tabaci* were found promising for the management of this pest. Seed treatment with imidacloprid 70WS @ 2.5 g per kg of seed provides protection for 25-30 days. Protection of seedlings in nursery by nylon net (200 mesh) covering for 25-30 days (Shivalingaswamy *et al*. 2006) followed by need based application of systemic insecticides after transplanting is able reduce the whitefly incidence. Spraying of systemic insecticides like imidacloprid @ 1 ml/3 lit of water or thiomethoxam @ 1 g/3 lit of water or dimethoate @ 2 ml/lit of water is recommended. Ameta and Kumar, 2005 reported that Spiromesifen 240 SC @ 500 ml/ha showed promising result in controlling whitefly in cotton.

Giant African snail

Giant African snail, *Achatina* (*Lissachatina*) *fulica* (Bowdich) (Stylommatophora: Achatinidae) is a polyphagous and one of the world's most damaging land snails. It is originated in east Africa and now spread all over the world (Raut and Barker, 2002) mainly the countries have tropical climates with warm, mild year-round temperatures and high humidity. In India, the occurrence of this snail has been reported in different states in 1914. It was first reported Aurangabad district during 1973 and in Konkan region during 1989. Being polyphagy, it is reported to feed on at least 500 different types of plant species (Capinera, 2011) and it voraciously feed many vegetables like colocasia, elephant foot yam, cucumber, cow pea, field bean, pea, ladies finger, tomato etc. Its sporadic outbreak noticed in about 300 ha in Sapur during 1998 and in 150 ha area of Nashik of Maharastra and causing havoc damage to the crops like bitter gourd, beans, bottle gourd, chilli, tomato and cauliflower (Puri and Mote, 2004).

Management

Adult snails are large enough and can be seen easily. They can be handpicked form their resting sites in the evening and early morning and can easily be destroyed. Clean cultivation and establishment of physical barriers like wrapping of tree trunks with copper foils around the trees etc. that restrict the movement of snails has long been practiced. Ravikumara *et al.* (2007) recorded highest number of snails attracted to papaya stem waste, followed by vegetable waste, fishmeal waste, areca leaf waste, banana sheath waste, sugarcane bagasse, leaf litter and farmyard manure. Sajeev (2011) adopted a control method of initially baiting the snail using cabbage leaves followed by spray with Tobacco decoction, made with Copper sulphate mixture (TDCS mixture). Beside these, Metaldehide bait (2.5%) is long being practiced to control this malacofaunal pest (Jayashankar *et al.* 2013). According to Javaregowda (2006), metaldehyde (2.5%) was most effective and registered highest mortality after one day of application, followed by monocrotophos bait. Basavaraju *et al.* (2001) observed 100% mortality under laboratory conditions using carbofuran (600 g carbofuran 3G + 60 kg rice bran + 6 kg jaggery/ha) bait against the snail.

Challenges and issues in management of emerging pests

Chilli gall midge

- Can be recognized only after symptoms are visualized
- Attack only the reproductive parts (flower bud, fruits) of the plants
- Damage is more severe under well irrigated conditions

Spotted pod borer

- Due to protective web difficult to control this pest with conventional insecticides
- Conceal in the web and there by also safe from its natural enemies
- Over lapping generations and short life cycle
- Need biointensive pest management (BIPM) strategy

Hadda beetle

- Polyphagy in nature and have diverse host range
- Efforts are to be directed for mass rearing and artificial release of *P. foveolatus*
- Egg stage is more vulnerable and hunts for suitable ovicide(s).

Solenopsis mealy bug

- Protective waxy coating over the body
- Insecticides are not much effective and they also cause residue problem
- Honey dew attracts the ants which give them protection against natural enemies
- Ants also held responsible for physical movement of this pest
- Biological control with Australian lady bird beetle, *Cryptolaemus montrouzeiri* and biopesticides like whit halo fungus, *Verticillium lecanii* may be encouraged

Serpentine leaf miner

- Wide host range makes them difficult to control; it can survive even in weeds also.
- Being an internal feeder it is difficult to control with insecticides
- Periodical monitoring using yellow sticky traps should be ensured.
- More emphasis should be given on Mary gold as trap crop.

Phytophagous mites

- Tiny and microscopic creature, difficult to observe
- Their symptoms often resemble with physiological disorders
- Cultivation of vegetables throughout the years
- Excessive use of insecticides with higher doses
- Red spider mite can spread from one place to another by means of air current *i.e.*, ballooning

Plume moth

- The pest is present during extreme summer in the month of May-June when the atmospheric temperature is around 45°C.
- Very few effective natural enemies are available in the nature
- They feed on apical buds and there by retarding the plant growth

Fruit flies

- Pupation takes place in soil, so difficult to control until soil treatment is done
- Hence internal feeder difficult to identify at early stage of infestation
- More emphasis should be given on behavioral management.
- Lack of promising natural enemies

Whitefly

- Wide host range and polyphagous nature made it difficult to control
- Indiscriminate use of insecticides lead them resurgence
- Yellow sticky trap to monitor the early population
- Need conservation of natural parasitoids *Eretmocerus* spp. and *Tetrastichus* spp.

Giant African snail

- It thrives in high humid areas
- It spreads through egg or juvenile stages
- Management required community based approach
- Very few known natural enemies

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