

## Sustainable integrated pest management of vegetable crops

**Vegetables crops like brinjal, okra, cabbage, cauliflower, tomato, beans and cucurbit are important vegetables cultivated in India. Several biotic and abiotic factors limit the productivity of vegetables, mainly disease and insect pests. Because of high susceptibility of vegetables to insects, farmers tend to apply chemicals for protective purposes. Also their high profitability combined with a lack of knowledge among the farmers has often led to improper use and hand of synthetic insecticides. This has resulted in great hazards to the environment and ecological consequences like destruction of natural enemy fauna, ill-effect on non-target organisms, residues in consumable product and the health of uses and imbalance between the insect pests and their natural enemies.**

INDIA ranks second in the production of vegetables after China. The existing area under vegetable cultivation in India is around 4-5 million ha. During the last 50 years, there is tremendous increase in vegetable production and therefore, India is largest vegetable producer with an estimated production of about 162.9 million tonnes from 9.40 million ha (Horticulture Statistics at a Glance Database, 2015). For the period, the total vegetable production was highest in case of West Bengal (23.045 thousand tonnes), followed by Uttar Pradesh (18.60 thousand tonnes), during 2013-14. India contributes 13.38% of total world production of vegetable. India occupies first position in cauliflower, second in onion and third in cabbage production in world. The importance of vegetables as protective food and as supplier of adequate quantities of vitamins, proteins, carbohydrates and minerals in human diets is known throughout the world. In near future, there is need of around 5-6 million tonnes of food to feed our billion Indian population.

### **Integrated pest management in vegetable crops**

The most important consideration of integrated pest management is that we should not depend on any one method for pest control. All options must be carefully considered.

**Surveys and surveillance and monitoring:** Timely and precise detection of insects with respect to their distribution and abundance on the related crops, will generate reliable data to support the specific kinds of control/management programmes.

**Cultural control:** Cultural control is a purposeful manipulation of the environment in order to make it less favourable to pests and at the same time more favourable to their natural enemies. It is based mainly on modifications in the time and manner of field operation for raising the crops. Cultural control is one of the older and cheapest modes of pest suppression.

**Crop location:** Crop diversity can be affected by varying the type of crops growing in adjacent field. Many insects can move quickly from one field to the next and between botanically related crops to obtain their requisite? Large-scale monoculturing of cotton, paddy, sugarcane and vegetable crop in India has resulted in a rapid increase in number and intensity of insect pest.

**Sanitation Tillage/removal of weeds:** Destroying or removing crop residues from fields is to eliminate pests, over wintering sites and reduce the spread of infestation. This may be achieved by ploughing directly or shredding, chopping, burning residue or raking and scooping them into piles for burning. Ploughing and tillage also expose soil-inhabiting insects and destroy volunteer plants and weeds that provide breeding sites for many pests. Summer ploughing results in high mortality of cutworms, white grubs, grasshoppers and many soil inhabiting caterpillars and beetles.

**Adjusting sowing/harvesting times:** Infestation by some pests can be avoided by adjusting the time of crop planting. The best example is sowing chickpea or mustard early in the season to avoid pod bores and aphid attack in respective crops. Similarly, by adjusting time of harvesting, crop can be saved from the attack of pest, which might become abundant later in the season.

**Seed rate:** Adoption of appropriate seed rate ensure proper stand, spacing and crop canopy and checks the unwanted growth of crop. High seed rate is recommended where removal of infested plants is helpful in minimising the incidence of insect pests viz. maize borer in maize. Low seed rate along with untimely rain and high temperature during sowing, drought conditions, favours termite attack.

**Crop rotation:** Farmers with their long experience have learnt to reduce pest problems by carefully rotating the crop belonging to one family with one of a different family. This practice is still very relevant. Rotating

**Table 1.** Tolerant varieties of some vegetables crops

Crop	Pest	Varieties
Tomato	Fruit borer ( <i>H. armigera</i> )	Arka Vikash, Pusa Gaurav, Pusa Early Dwrf, Punjab Keshri, Punjab Chhuhra, Pant Bahar, Azad, Avinash-2, Hemsona, Krishna, Sartaj
Brinjal	Shoot and fruit borer ( <i>L. orbnalis</i> ), Aphid, jassid, thrips, whitefly	SM17-4, PBr 129-5 Punjab Barsati, ARV 2-C, Pusa Purple Round, Punjab Neelam, Kalyanpur-2, Punjab Chamkila, Gote-2, PBR-91, GB-1 GB-6
Cabbage	Aphid ( <i>Brevicoryne brassica</i> )	All season, Red Drum Head, Sure Head, Express Mail
Cauliflower	Stem borer ( <i>Hellula undalis</i> )	Early Patha, EMS-3, KW-5, KW-8, Kathmandu Local
Okra	Jassid ( <i>Amrasca biguttula</i> )	PBR-2, PBR-6, Arka Niketan, Pusa Rathar, PBR-4, PBR-5, PBR-6
Onion	Thrips ( <i>thrips tabaci</i> )	PBR-2, PBR-6, Arka Niketan, Pusa Rathar, PBR-4, PBR-5, PBR-6
Round gourd	Fruit fly ( <i>B. Cucurbitae</i> )	Arka Tinda
Pumpkin		Arka Tinda
Bitter gourd		Arka Suryamukhi Hissar-11

**Table 2.** Pheromones and their purpose against insect pest

Host plant	Insect pest	Pheromone	Purpose
Tobacco, cotton, vegetables	Tobacco caterpillar, <i>Spodoptera litura</i>	(Z, E) 9,11-Tetradecadenyl acetate and (Z, E) 9,12-dienyl acetate	Monitoring and mass trapping
Okra	Spotted bollworm, <i>Earias</i> spp.	(E,E) 10,12-Hexadecadienal	Monitoring
Cabbage	<i>Thysanopulsia orchalcea</i>	(Z) 7-Dodecenyl acetate	Monitoring
Cucurbits	<i>Bactrocera cucurbitae</i>	4(p-Hydroxyphenyl)-2-butanoyl acetate	Monitoring

groundnut with maize will reduce the attack of white grubs.

**Intercropping:** Growing of two or more crops together helps in alleviating certain pest problems by making micro-climate less favourable for pest. It also hinders the free movement of pests amongst the plants of some species and those increasing the environmental resistance for the pest.

**Trap crop:** The trap crop must be distinctly more attractive to the pest than the main crop. For example African marigold against fruit borer in tomato is a very effective trap crop. Planting Indian mustard as a trap crop for the management of insect pest of cruciferous vegetable is effective.

**Water and fertilizer management:** High levels of nitrogen fertilizers significantly increase the incidence of most of the insect pest including yellow stem borer, leaf folder, green leaf hopper in rice; leaf folder, white fly and boll worm in cotton; internode, stalk borer and pyrilla in sugarcane.

**Host plant resistance:** Managing insects' pests and diseases using resistant plant varieties is perhaps most effective economical and environment friendly way. Resistance varieties are of special significance for India, where holdings are small and farmers are not equipped to take up other methods and pest control.

**Mechanical:** It involves use of mechanical or manual operation and mechanical barriers for the control of pests. Hand picking and destruction of inactive adults, conspicuous egg mass and large sized larvae can be

collected and killed. Hand picking of hairy caterpillars, leaf rollers, tobacco caterpillars, cabbage butterfly, mustard saw fly, white grubs, may reduce the damage.

**Light trap:** Light traps for attracting and mass killing of several species of moths and beetles are used as a control measure as some insects are phototaxic. The traps could be useful for monitoring the population of important insect pest in an area.

**Pheromone trap:** A recent approach involves the development of haloacetate analogous of natural pheromones of a number of insects.

### Biological control

#### Parasitoid

Parasitoid means parasite like. Although, parasitoids are similar to true parasites which are generally much smaller than their hosts.

#### Predators

They consume several to many preys over the course of their development. They are free living, and they are usually as big or bigger than their prey. Examples include Ladybird beetles, *Chrysoperla carnea*.

#### Pathogen

Microorganisms like bacteria, viruses, fungi, protozoa and nematodes develop diseases to the pest and thus help in killing pest. This includes

**Fungus:** *Beauveria bassiana*, *Metarrhizium anisopliae*, *Nomuraea rileyi* - Used for soft bodied insects, soil dwellers

**Table 3.** Biocontrol agents recommended in vegetable crops

Bioagent	Dose	Target pest
<i>Trichogramma brassilinsis</i>	2,50,000 parasitized eggs/ha (Inundative release)	Okra shoot and fruit borer tomato fruit borer
Chrysoperla Zastrowi Arabica	50,000 first instar larvae/ha (weekly release)	Okra aphid, Cabbage aphid
HNPV	250 LE/ha (10 days interval)	Tomato fruit borer
SNPV	250 LE/ha (10 days interval)	<i>Spodoptera litura</i>
<i>Bacillus thuringiensis</i>	500 g ai/ha (10 days interval)	Diamondback moth, Shoot and fruit borer of brinjal and okra, Tomato fruit borer
Kairomones	Effect	Natural enemies
Tricosane	Preconditioning and reinforcing agent	Chrysopid (increased predation)
Alpha- Tryptophan	Ovipositional attractant Singh (2001)	Chrysopid, <i>Trichogramma</i> , Coccinellid (Increased ovipositing)

and lepidopterous larvae. Spraying of *B. bassiana* 1x10<sup>4</sup> cfu/g two times with a week interval satisfactorily managed whitefly nymphs and adults. Spraying of *B. bassiana* @ 2.5 kg/ha was found effective against shoot and fruit borer, *L. orbonalis* in brinjal and in okra also found effective against *Earias* sp.

**Bacteria:** *B. thuringiensis* - Used against diamond black borer, fruit and shoot borer of brinjal. Bt @ 0.5 kg/ha + removal and destruction of infested twigs fruits and fallen leaves were found most effective against shoot and fruit borer, *L. orbonalis* in brinjal and application of Bt in okra was found effective against *Earias* sp.

**Virus:** Ha-NPV - Used against tomato fruit borer while S-NPV- is used against tobacco caterpillar. Ha NPV @ 300 LE was found effective against tomato fruit borer, *H. armigera*. The sprays of Ha NPV at 250 larval equivalents/ha has been found to be effective in controlling fruit borer.

### Entomopathogenic nematodes

Nematodes associated with insects that parasitize, cause disease and kill the insects are called Entomopathogenic nematodes (EPN). Infective juveniles penetrate the host via natural body openings, such as mouth, anus, spiracles and/or also directly through cuticle. The symbiotic bacteria is released in the haemocoel of the host insect, causing septicaemia and death of the host, usually within 24–48 h of infection.

### Botanicals

NSKE sprays are recommended on a variety of crops such as cabbage, cauliflower, tomato and cucurbits against all pests, on tomato and cucurbits against serpentine leaf miner, and on beans against stem fly, *Ophiomyia phaseoli*. In cabbage and cauliflower, NSKE sprays provided excellent control of all the pests and the crop could be raised without a single insecticide application

### Selection of chemicals may sustain the IPM system

These insecticides should be used considering certain aspect like waiting period of chemical, economic threshold level and initiation of control measures through pheromone /light trap catches.

### Integrated pest management of vegetables crops

#### *Pests of brinjal*

#### *Shoot and fruit borer (Leucinodes orbonalis Guenee)*

The major host plants of the pest are Brinjal. The young caterpillars bore into the tender shoots near the growing points, flower buds or the fruits. A single caterpillar may destroy as many as 4-6 fruits. Attacked fruits become unfit for consumption and marketing. Infestation up to 70% has been recorded.

#### *Brinjal stem borer (Euzophera perticella Rag.)*

The caterpillars cause the damage and feed exclusively in the main stem. It enters the main stem and makes tunnel, which result either in stunting of growth or wilting of whole plant, prior to yellowing of leaves.

#### **Pests of tomato**

#### *Tomato fruit borer (Helicoverpa armigera Hub.)*

The major host plants of the pest are okra, onion, brinjal, potato, chillies, tomato, cowpea, beans, gram, maize, cotton, pea, pigeon pea etc. The younger larvae feed initially on the foliage for a while and later bore into the green fruits. The larva while feeding, thrusts its head into the fruit leaving the rest of its body outside. Early instars feed on leaves and fruiting bodies. Later they bore into fruits.

#### *Tobacco caterpillar (Spodoptera litura F.)*

Major host plants of this pest are brinjal, cabbage, cauliflower, capsicum, cucurbits, okra, *Phaseolus*, potato, sweet potato and species of *Vigna* and other wild hosts. After hatching, the larvae feed gregariously together and later they spread out and feed individually.

#### *Serpentine leaf miner (Liriomyza trifolii Burgess)*

Major host plants of the pest are okra, onion, cucurbits, beans, potato, brinjal, crucifers and other crops. Damage is due to mining into leaves and petiole by the larva. The photosynthetic ability of the plants is often greatly reduced as the chlorophyll – containing cells are destroyed. Severely infested leaves dry up and fall.

#### *Whiteflies: (Bemisia tabaci Gene.)*

The major host plants the pest are okra, crucifers, cucurbits and solanaceous crops. On hatching, the first instars larva (only mobile stage) or crawler moves to a

suitable feeding site on the lower leaf surface where it moults and becomes stationary throughout the remaining sates.

### **Pest of chilli**

*Thrips (Scirtothrips dorsalis Hood)*

This is a polyphagous pest. Besides chillies, it feeds on tomato, cotton, castor, sunflower, mango and citrus. The nymphs and adults lacerate and suck the cell sap from leaves and tender parts of the plants and causes the leaves to shrivel and curl upward. In case of severe infestation, there is a malformation of leaves, buds and fruits. The attacked shoots hardly develop and the leaves fall off. They are also responsible for transmitting the leaf curl disease in chillies.

### **Cruciferous Vegetables**

*Diamondback moth (Plutella xylostella L.)*

*P. xylostella* is considered as the main insect pest of crucifers, particularly cabbage, broccoli and cauliflower. The newly hatched larvae cause serious damage to crops like cabbage, cauliflower by scrapping the leaf tissues, and they grow older, bite holes in them and render the vegetables unfit for human consumption.

*Cabbage caterpillar (Pieris brassicae L.)*

The major host plants of this pest are cabbage, cauliflower, other cruciferous vegetables and mustard. Freshly hatched caterpillars scrape the leaf surface. The older larvae eat up the leaves from margins, leaving intact the main vein. Sometimes all the leaves of entire plant are eaten away.

*Cabbage head borer (Hellula undalis F.)*

It is major pest of cole crops in tropical and subtropical regions. Younger seedlings are most susceptible to the attack of these pests. The caterpillar in initial first two instars mine the leaves. Later on, they feed on the leaf surface and bore into the heads of the cauliflower and cabbage.

*Cabbage semilooper (Thysanoplusia orichalcea F.)*

It is a polyphagous pest and defoliates a wide range of crop plants such as cabbage, turnip, lettuce, cotton, chicory groundnut, sun hemp, tobacco, sunflower, tomato, potato, chickpea and soybean. The younger larvae infect damage by biting holes into the leaves. The later stages larvae completely defoliate the plant during severe infestation.

*Aphids (Myzus persicae sulzer and Brevicoryne brassicae L.)*

Aphids appear in November and remain active till April. Both nymphs and adults are similar in appearance. Direct feeding on young growth leads to wilting of plants. Early attack may lead to stunted growth. Symptoms of viruses transmitted by *B. brassicae* include mosaic, chlorotic and necrotic lesions on leaves. *M. persicae* is the most important aphid virus vector. It has been shown to transmit well over 100 plant virus diseases.

*Tobacco caterpillar (Spodoptera litura F.)*

Major host plants of this pest are brinjal, cabbage, cauliflower, capsicum, cucurbits, okra, phaseolus, potato, sweet potato and species of Vigna and other wild hosts. Larvae are very active at night. Heavy infestation in the form of outbreaks can severely defoliate the crop.

### **Pests of malvaceous vegetables**

*Pests of okra*

*Shoot and fruit borer (Earias vittella F.)*

It is a major pest of Malvaceous crops like okra and cotton. Both nymphs and adults of leafhoppers are seen on the underside of the leaf sucking the sap. The initial symptoms of leafhopper damage are yellowing of leaves, followed by crinkling around the margins and upward curling of leaves. Severely affected plants have stunted growth.

*Red Spider mites: (Tetranychus urticae Koch)*

The pest is polyphagous and is known to feed on more than 150 species of plants including cucurbits, brinjal and okra etc. The damage is caused both by nymphs and adults. A large number of webs are formed on the leaves under which the pest sucks the cell sap. The affected leaves dry up and finally wither away giving unhealthy appearances. Webbing interferes with the plant growth and reduction in yield.

### **Pest of cucurbits**

*Melon fruit fly (Dacus cucurbitae Coq.)*

*B. cucurbitae* is a serious pest of cucurbitaceous crops particularly bitter melon and musk melon and have dark patch on the outer margins of their wings. The larvae tunnel in the fruit, contaminating them with frass and providing entry points for fungi and bacteria, which cause the fruit to rot. The infestation varies from 50-100% in different cucurbitaceous crops.

*Red pumpkin beetle (Raphidopalpa foveicollis Lucas)*

The host plants of this pest are pumpkin, cucumber, ash guard, bitter melon and melons. The grubs live in soil feeding on roots and underground stems of vines and sometimes on fruits in contact with the soil. The beetles feed on aerial parts of the plants like cotyledons, flowers and foliage by biting holes into them. The damage by beetles is detrimental to the cotyledon stage of the seedlings.

*Leaf eating caterpillar (Diaphania indica Saunders)*

It is an irregular and sporadic pest of cucurbits becoming serious currently on cucumber, gherkins and bitter melon. Initially after hatching, caterpillars feed on the leaves by binding them together. Some time the flowers are also infested. The vines are cut from one side and the terminal parts become yellowish and dry up.

Despite use of pesticides, insect pests and diseases cause considerable losses in vegetables. Moreover, many insect pests have developed resistance to insecticides used to control them, implying repeated applications of insecticides and increase in the cost of protection, secondary outbreak and pest resurgence. There is a need to realize to potential of indigenous bio-control agents and attention should be given to conserve them. The newer technologies and practices embedded in IPM provide better protection against insect pests; improve crop yields and net benefits to the farmers.

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