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Review Article

An Overview of Integrated Pest Management (IPM) of Vegetable Crops

P Bhumita*, RK Padamini, Ch Chanbisana and Punabati Heisnam

Central Agricultural University, Imphal,Manipur, India

***Corresponding Author:** P Bhumita, Department of Entomology, College of Agriculture, Central Agricultural University, India.

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Abstract

India has achieved self-sufficiency and a good degree of stability in food production. Which created an urgent need for providing health security to our population by supplying nutrition through a balanced diet. Vegetables form the most important component of a balanced diet. Some constraints in production of vegetable crops are the non-availability of quality seeds, the high cost of production due to excessive use of pesticides to control pests and diseases, and many others. Among all, insect pest and disease infestation are the major constraints. The losses of crops caused by insect pests are quite high and assessment of the correct percentage of yield loss is a difficult task. There are different major pests damaging the crops and leading to a decline in the production with an estimate of 25-45% losses. Synthetic pesticides are the sole panacea to manage the pest by farmers even today. Indiscriminate use of pesticides has led to serious problems such as the destruction of natural enemy fauna, effect on non-target organisms, pesticides residues in vegetables and resistance of pests to pesticides. IPM (integrated pest management) can minimize these negative externalities by adopting non-hazardous, environment friendly, economic and viable control methods to get good and healthy produce.

Keywords: Integrated Pest Management; Vegetable; Key Pest

Introduction

India ranks second in fruits and vegetable production in the world, with an estimated production of 107.24 million tonnes of fruits and 204.84 million tonnes of vegetables (Source: PIB, Ministry of Agriculture and Farmers Welfare). Total Horticulture production in 2021-22 is estimated to be 342.33 million tonnes with an increase of 2.3% over the year 2020-21.

Crops	2021-22 (First Advance estimate)		2021-22 (Second Advance estimate)	
	Area	Production	Area	Production
Total Fruits	6976	102924	7019	107102
Total Vegetables	11065	199882	11280	204613

Table 1: Production of fruits and vegetables in India.
(**Source:** PIB, Ministry of Agriculture and Farmers Welfare, 2022).

Some constraints in the production of horticultural crops are non-availability of quality seeds, high cost of production due to excessive use of pesticides to control pests and diseases, declining soil fertility and many others. Among all, insect pest and disease infestation are the major constraints. The losses of crops caused by insect pests are quite high and assessment of the correct percentage of yield loss is a difficult task. An extensive survey conducted during the early 1960s shows that fruits suffer 25 % losses and in actual the losses in Indian agriculture are estimated from time to time [5,12]. Crop losses in major vegetable crops range from 46 to 100% due to incest pest and 5 to 90 % due to diseases.

Among the vegetables, tomato is damaged by fruit borer (*Helicoverpa armigera*) serpentine leafminer (*Liriomyza trifolii*), whiteflies, (*Bemisia tabaci*) and thrips; brinjal by fruit and shoot borer (*Leucinodes orbonalis*), hadda beetle (*Epilachna viginctioctopunctata*), aphids (*Aphis gossypii*); chilli by thrips, mites, fruit borer (*Spodoptera litura*); whereas potato is infested by cutworms, white grubs (*Holotrichia longipennis*), potato tuber moth (*Pthorimea opercullela*), aphids, leafhopper and whiteflies. The cruciferous crops are attacked by cabbage butterfly (*Pieris rapae* and *P. brassicae*), DBM (*Plutella xylostella*), cabbage aphids (*Brevicoryne brassicae*) and cucurbits by Fruit fly (*Bactrocera cucurbitae*) and other polyphagous pests.

There are different major pests damaging the fruit crops and leading to a decline in the production with an estimate of 25-45% losses. Some of the major crop pest are banana aphids, rhizome weevils, citrus pests like fruit fly, aphids, leaf miner, citrus butterfly, citrus stem borer, mango stem borer, spider mites etc. Agro-climatic conditions of Noth Eastern Hill region of India are conducive to the development and multiplication of insect pests and their natural enemies. Synthetic pesticides are the sole panacea to manage the pest by farmers even today. Indiscriminate use of pesticides has led to serious problems such as destruction of natural enemy fauna, the effect on non-target organisms, pesticides residues in vegetables and resistance of pest to pesticides. Sikkim being an organic state there is a need to develop a standard organic pest management practice. IPM (integrated pest management) cannot eliminate but can minimize these negative externalities by adopting non-hazardous, environment friendly, economic and viable control methods like tolerant/resistant varieties, soil solarization, alternation in sowing/planting time, use of predators, parasite and microbial pathogens, pheromone traps, trap crops, genetically engineered transgenic plants etc., to get good and healthy produce. Thus, an attempt has been made in this topic to give an insight into the major pest problem in horticultural crops and their IPM approaches.

Why IPM?

One needs to understand the history of pest management and know how the scuffle between man and crop pests evolved. Before the synthetic pesticides, the growers manage pest problems with the combination of various techniques. Those strategies are ones that are still used today in agriculture.

In 1940's, The DDT Miracle-was the answer to all our problems and it was like everyone was trained to use chemicals. After a point the problems of Resistance to chemicals, and Secondary Pest Outbreak were encountered. The increasing speed and high rate of problems due to over use of pesticides led to development of IPM approach, since 1959, IPM has proved to be one of the best ways to manage pest problems in agriculture.

What is IPM?

FAO panel of Experts [2]. define it as a "Pest management system that, in the context of the associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in a compatible manner as possible and maintain pest populations at levels below those causing economic injury".

IPM is a long-term approach to managing pests by combining biological, cultural, and chemical tools in a way that minimizes economic, health and environmental risks.

Cultivation is long term work and we need a management practice that is useful in long term. With the experience with chemical controls, the pest control techniques we adopt should be eco-friendly.

IPM is an approach to solve the pest problems, not a technique. It changes with time and may vary from field to filed, crop to crop, and place to place but the overall approach based on the essential components is always the same.

Major insect pests of vegetables

Table 2 shown below

IPM Strategies

Cultural and mechanical

- Grow less susceptible genotypes of tomato like Rupali, Roma, Pusa Red Plum
- Crop rotation of same group of vegetables, *i.e.* crucifers, cucurbits and some solanaceous crops should be avoided to reduce stem borer etc.
- Collect and destroy the infected fruits and grown-up larvae.
- Clean cultivation, deep ploughing and off season ploughing to expose the hibernating pupa to sunshine and predators.
- Regular clipping of infested branches and shoots and burning them reduce the incidence of Eggplant fruit and shoot borer (EFSB), stem borer and mites.
- Planting of marigold (40 days old) as a trap crop with 16 rows of tomato (25 days old seedlings) attracts the *Helicoverpa armigera* Hub. Collection and destruction of larvae from marigold flowers.
- Pusa Ruby checked the population of jassids, whitefly and virus infection [10].
- Application of neem cake in soil @ 250 kg/ha before nursery

Major insect pests				
Sl. No	**Common name**	**Scientific name**	**Order: family**	**Symptoms**
1.	Tomato fruit borer	*Helicoverpa armigera* Hub.	Lepidoptera: Noctuidae	Caterpillars bore the fruit
2.	White fly	*Bemisia tabaci* Gennadius	Hemiptera: Aleyrodidae	Both nymph and adult suck the sap from the leaves and leads to curling and cupping
3.	Aphids	*Aphis gossypii* Glover *Myzus persicae* (Sulzer)	Hemiptera: Aphididae	Nymph and adult suck the sap from the leaves
4.	Jassid/Leaf hoppers	*Amrasca biguttula biguttula* (Ishida)	Hemiptera: Cicadellidae	Nymph and adult suck the sap causing hopper burn
5.	Serpentine leaf miner	*Lyriomyza trifolii* (Burgess)	Diptera: Agromyzidae	Larvae mines into the leaves, leading to drying of leaves
6.	Shoot and Fruit borer	*Leucinodes orbonalis* Guenee	Lepidoptera: Pyralidae	Larva bores into tender shoots resulting to tip drying and bores into developing fruits and bore hole plugged with excreta
10.	Spotted leaf beetle/ Hadda beetle	*Henosepilachna vigintioctopunctata* (Fab.)	Coleoptera: Coccinellidae	Adults and grub feed on the leaves' chlorophyll tissue between veins resulting in the skeletonization of brinjal leaves
11.	Leaf roller	*Eublemma olivacea* Walker	Lepidoptera: Noctuidae	Caterpillars fold leaves from the tip downward and feed within by scrapping the green matte, folded leaves wither and dry up.
12.	Thrips	*Scirtothrips dorsalis* Hood	Thysanoptera: Thripidae	Adults and nymphs lacerate the leaf tissue which leads to inward curling of the leaves, stunted growth and flower buds and fruit dropping.
13	Tobacco caterpillar	*Spodoptera litura* (Fab.)	Lepidoptera: Noctuidae	Caterpillars act as defoliator during the vegetative stage and bore into fruits during fruiting stage of the crop
14	Potato tuber moth	*Phthorimaea operculella* (Zeller)	Lepidoptera: Gelechiidae	Caterpillar mine the leaves, petiole and terminal shoots causing wilting After tuberization, the larvae enter the tubers and feed on them
15	Cut worms	*Agrotis ipsilon.* (Hufnagel)	Lepidoptera: Noctuidae	Caterpillar feed on young leaves and also cut tender seedlings and stems at ground level
16	White grubs	*Brahmina coriacea* (Hope) *Holotrichia longipennis* (Blanchard)	Coleoptera: Melolonthidae	Both grubs and adults feed on underground plant parts of various crops.
17	Diamond Back Moth	*Plutella xylostella* (Linnaeus)	Lepidoptera: Pluttellidae	Mining and skeletonization of cabbage leaves
18	Cabbage butterfly	*Pieris brassicae* (Linnaeus)	Lepidoptera: Pieridae	Defoliation of the leaves by caterpillar
19	Cucurbit fruit flies	*Bactrocera cucurbitae* (Coquillett)	Diptera: Tephritridae	Maggots feed on pulp and seeds of fruit. Infested fruits become soft and rotten, premature falling of fed fruits
20	Red ants	*Dorylus orientalis* Westwood	Isoptera: Formicidae	Feeds on the underground portion of the stem and roots resulting in wilting and drying of the plants
21	Termites	*Odontotermes sikkimensis*	Isoptera: Macrotermitidae	Feeds on underground portion of the plants, drying and wilting of the plants

Table 2

sowing/transplanting.

- Soil solarization using transparent polythene sheets 60-100 gauge thick on nursery beds for about 15 to 21 days.
- Use of yellow pan/sticky traps for sucking pests @ 10/ha.
- Irrigating the field at 60-80% field capacity reduces tuber infestation by Potato tuber moth (PTM).
- The use of nitrogenous fertilizers at higher doses also kills the first instar white grubs.

Bio-rational

- Abamectin @ 1.4 ml/litre is effective in controlling leaf miner and recorded 75-100% larval mortality [8].
- Installation of pheromone traps @ 5/ha for monitoring *H.armigera* and *S.litura*.
- *Bacillus thuringiensis* Berliner var. *kurstaki* (HD-1) @ 2g/litre caused 79.38% mortality of second instar larvae of *H.armigera* [1].
- Spray HaNPV at 500 LE/ha along with cotton seed oil at 300g/ha to kill larvae.
- *B.t.* formulations *i.e.,* Halt @ 1 kg/ha was reported highly effective in reducing the *H.armigera* larval population and per cent fruit damage with increased fruit yield and high cost benefit ratio [7].
- Oxymatrine 1.2% EC @ 500 to 750 ml/ha was effective against EFSB and Red spider mites [13].
- Two applications of neem oil @ 10 ml/litre at three weeks intervals was effective against the sucking pests [9].
- Seed treatment with *Tricoderma viride* @ 4g/kg of seed before sowing is effective
- Spraying of NSKE 5% at 15 days interval after15 (days after transplant) DAT.
- Application of Thuricide dust @ (3 x 10^6 spore/gm) at the time of flowering or fruit set control EFSB effectively.
- Installation of pheromone traps
- The plant products *viz.,* neem oil @ 2%, neembicide @ 2ml/litre, neem cake, NSKE @ 5% were able to reduce the fruit and shoot borer damage in brinjal.
- Vermicompost (2.5 t/ha) or neem cake (0.5t/ha) followed by four sprays of NSKE 5% and neemazal 10,000 ppm at 2, 5, 7 and 11 weeks after transplanting recorded less population of thrips, mites and leaf curl index [3].
- Vermitec 1.9 EC @ 0.56ml/litre recorded a low incidence of thrips and mites [14].

Biological

- Release of egg parasitoid, *Trichogramma chilonis* @ 1, 00,000 per ha five times at weekly intervals against *H. armigera*, starting with initiation of egg hatching/moth catches [4].
- Bio-agents like *Chrysoperla carnea, Coccinella septempunctata,* syrphids, *Scymnus* sp. predate on aphids and whiteflies.
- *Trathala flavo-orbitalis,* a dipteran fly and a mermethid nematode were found as natural enemies of *L.orbonalis* [11].
- Release *Chrysoperla carnea* @ 2 grubs per plant to control aphids and other soft bodied insects
- Inundative release *T. chilonis* @ 50,000 /ha coinciding with infestation
- Parasitoids: *Broscus punctatus* Dist and *Liogryllus bimaculatus* Linn, *Macrocentrus collaris* (Spin), *Netelia ocellaris* (Thomson), *Coelichneumon sp.nr truncatulus* Thomson, *Periscepsia carbonaria* Panzer and *Turanogonia chinensis* Wiedemann parasitizised *A.ipsilon* and *A.segetum* under natural field conditions.
- Entomogenous fungus, *Metarrhizium anisopliae* (Meld.) pathogenic bacteria *Bacillus thuringiensis* Berliner and entomophilic nematode, *Steinernema (Neoaplectana) sp*. regulates cut worm populations.
- Scollids, *Campsomeris collaris* F., *Scolia aureipennis* Lepeletier and *S.pustulata* Magr., pathogens, *Bacillus popilae* Dutky, *Metarrhizium anisopliae* (Metch), *Beauveria brongniartii* (Sacc.) Petch, Isyr and *B.tenella* (Del.), entomophillic nematode, *Steinernema sp.* for the control of white grub
- Four releases of *Chelonus blackburni* Cameron @ 15000 adults/ha/release at weekly intervals, *Copidosoma koehleri* Blanchard @ 50000 adults/ha/release and *Trichogramma chilonis* Ishii @ 50000 adults/ha/release at weekly intervals and three sprays of *Bacillus thuringiensis* Berliner @ 1kg/ha at 10 days interval [6] against PTM.

IPM for Tomato fruit borer

- Use of tolerant varieties like Punjab Kesri, Roma AC, Punjab Chuhara, Pant Bahar, Azad, Pusa Hybrid-4.
- Deep summer ploughing exposes the larvae and pupae to sunlight and predators.
- Planting of marigold (40 days old) as a trap crop with 16 rows of tomato (25 days old seedlings) attracts the pest. Collection and destruction of larvae from marigold flowers.
- Use of pheromone traps (5/ha) for early pest detection.
- Use of neem based insecticides.
- *Trichogramma brasiliense* @ 2, 50,000 - parasitised eggs/

ha (Inundative release) during peak flowering stage (or) *T.pretiosum* @ 1.0 lakh/ha six times from flower initiation stage at weekly intervals brings significant control.

- Spray HaNPV @ 250LE with jaggery (10g/lit), soap powder (5g/litre) and a tinopal (1ml/litre) during evening hours or need based application of endosulfan @700g a.i. /ha.
- Natural enemies: *Bracon brevicornis, Campoletis chlorideae, Trichogramma chilonis, Trichogrammatoidea* sp. are some of the important parasitoids recorded from India.

IPM for Whitefly

- Uproot and destroy the diseased leaf curl plants
- Remove alternate weed hosts
- Use a yellow sticky trap to attract and bill insects
- Spray neem oil 0.5% along with teepal 1 ml/lit
- Encourage activity of parasitoids *Eretmocerus mesii* and predator coccinellids, *Brumus* and *Chrysoperla*.

IPM for Eggplant fruit and shoot borer

- Use of tolerant/resistant varieties like Arka Kesav, Kalyanpur-2, Punjab Chambila, Pusa Purple Round.
- Intercrop with coriander/fennel as 3 single line or double line or as a border crop.
- Removal and destruction of infested fruit and shoot.
- Installation of pheromone traps @ 100 traps/ha at a distance of 10x10m and lure placement after 45 days.
- 4-5 release *T.chilonis* @ 50,000 parasitized eggs/ha coinciding with infestation.
- Application of NSKE @ 4% or *Bt.* @ 0.5 kg/ha.
- Need based application of Cartaphydrochloride @ 2g/litre water.
- Spraying Cypermethrin @ 0.125% at 2% flower bud damage threshold is very effective.
- Spray Fenvelarate @ 0.01% or Cypermethrin @ 0.125% once at 15-20 days from flowering.

IPM for Tobacco caterpillar

- Clean cultivation to expose *Spodoptera* pupae to natural enemies.
- Use pheromone traps to predict *Spodoptera* egg laying.
- Hand picking and mechanical destruction of egg masses and caterpillars during the early stage of attack.
- Application of neem kernel extract during the early stages of crop growth.
- Spray SLNPV @ 250LE with jaggery (10g/lit), soap powder (5g/litre) and a tinopal (1ml/litre) during evening hours.
- Spray 400ml Malathion 50EC or 370ml endosulfan 35EC in 250 litres of water per acre and repeat the spraying at 10 days intervals.
- Natural enemies: *Bracon brevicornis, Campoletis chlorideae* and *Eriborus argenteopilosus* are the larval parasitoids, *Trichogramma chilonis* an egg parasitoid, *Bacillus thuringiensis* (bacteria), *Beauveria bassiana, Metarrhizium anisopliae, Nomuraea rileyi* (fungi) and *Nucleo polyhedrosis virus* (NPV) are some of the entomopathogens recorded.

Conclusion

As we have discussed above, we have seen that insect pests are really a problem for farmers as they cause a reduction in their yield and also the high cost of inputs for controlling them. To increase production and productivity there is a need to replace the existing chemical oriented plant protection techniques with economically viable and environmentally safe methods like Integrated Pest Management (IPM). Also, Bio-intensive IPM should be developed and encouraged because it will help to reduce the dependence on chemical pesticides and ecological deterioration. Bio-intensive Integrated Pest Management (BIPM) includes biopesticides derived from microbial, parasitoids, predators, botanicals and all conventional non-chemical methods of pest control. We should also encourage the pest management practices under organic farming conditions and chemical insecticide should be used only when the pest's damaging capacity is nearing to the threshold level showing a high risk in the crop production.

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