Popular Article

e-ISSN: 2583-0147

Volume 2 Issue 10
Page: 0258 – 0264

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Pesticide Free Vegetable Production

In India, insect pests are major constraints in vegetable production. The vegetable growers using chemical pesticides to minimize the loss due to pest and diseases, several alternate ways are available for the pests and they may yield pesticide free vegetable produce. The cultural methods *viz.,* preparation of land, following crop rotation, selection suitable variety, crop management practices and use of traps may give better response in reducing the pest incidence. The biological methods like use of plant products, predators, parasitoids, and microbial bio-agents are now a days a boon in pest management in vegetable. Hence, combined application of cultural as well as biological methods against the pests can be way for production of pesticide free vegetables.

INTRODUCTION

India produces almost all the crops including agricultural, horticultural crops and commercial crops (Vanitha *et al.,* 2013; APEDA 2020). India earns foreign exchange significantly by exporting horticultural crop commodities like fruits, vegetables and flowers every year. The vegetables contribute to a significant proportion of area and production with major crops like brinjal, tomato, okra, cabbage, potato, onion and cucurbits and they are being cultivated in the country throughout the crop seasons (NHB, 2018).

Vegetables contain vital source of proteins, vitamins, minerals, dietary fibers, micronutrients, antioxidants and phytochemicals in human daily diet. They provide nutrition our very diet apart from this they contain array of potential phytochemicals like anti-carcinogenic principles and anti-oxidants like flavonaoides, glucosinolates and isothyocyanates which will help in combating various disorders. Even though production and productivity of vegetable crops increased in recent years, the vegetable crops encounter by a number of insect pest all along their growth and development period. Apart from direct damage, they also act as vectors of number of viral diseases through

persistent, semi-persistent and non-persistent manner (Rai *et al.,* 2014). Various researchers estimated crop losses to the tune of 30-40% at different crop growth stages (Rai *et al.,* 2014). The insect pests attack vegetable crops at various crop stages and cause significant reduction in yield and quality (Sharma *et al.,* 2013). They can damage vegetables both in protected structures (net house, polyhouse) and open field with variable damage (Rai *et al.,* 2014).

In some of the situations, minor pests emerged as major problem due to the shift in seasons and favorable environmental conditions (Vanitha *et al.,* 2013; Rai *et al.,* 2014). Changes in cultivation practices, like intensive mono cropping, introduction of high yielding but susceptible varieties/hybrids which uses high inputs under changing climatic scenario are the major factors leading to a pest outbreak and epidemics.

Sap feeding insects include leaf hoppers, aphids suck the plant sap leading to yellowing, crinkling, downward curling and death of the foliage. Nymphs and adults are mostly involved in feeding (Shivalingaswamy *et al.,* 2002). Vegetables like brinjal, cabbage, tomato, potato, chillies, onion and cucurbits infested by majority of insects. Aphids, Jassids, Whiteflies, fruit and shoot borer, hadda beetle, mealybug, leaf minor, tubermoth, head borer and leaf hoppers are major pests causing maximum damage at different crop growth stages.

Major pests attacking vegetables are, shoot and fruit borers causing damaging symptoms like withered terminal shoots, bore holes in stem and fill-up with fecal matter. They also cause shedding of flower buds, leaf drying, larvae and adult can bore the fruits and cause extensive damage. Leaf rollers which extensively feed on leaves, fold leaves from tip to downwards following withering and death of the leaves. This directly affects the economy as India is exporting fresh fruits and vegetables to different countries earning significant foreign exchange. About 16.27% of the foreign income comes from export of vegetables (Shivalingaswamy *et al.,* 2006). Insect pests of much significance to vegetable crops and yield loss are given (Table 1). Whereas Post-harvest losses especially in vegetables and fruits are presently in the range of 20 to 30 percent. It contributes directly to higher costs and reduces availability of these commodities. In order to avoid losses due to pest and disease, the farmers are using huge amount of pesticide chemicals and which are hazardous to the environment. The pesticides usage was increased from 24.32 thousand tones in 1970-71 to 75 thousand tones in 1990-91and later it slowed down.

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

Crop and pest	Yield loss
Tomato	24-73
Fruit borer (*Helicoverpa armigera*)	
Brinjal	11-93
Fruit and shoot borer (*Leucinodes orbonalis*)	
Chillies	12-90
Thrips (*Scirtothrips dorsalis*)	
Mites (*Polyphagotarsonemus latus*)	34
Okra	
Fruit borer (*H. armigera*)	22
Leafhopper (*Amrasca biguttula biguttula*)	54-66
Whitefly (*Bemisia tabaci*)	54
Shoot and fruit borer (*Earias vittella*)	23-54
Cucurbits	
Fruit fly	
Bitter gourd	60-80
Cucumber	20-39
Ovygoud	63
Muskmelon	76-100
Snake gourd	63

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

The unscientific and indiscriminate use of chemical pesticides brought into various problems like residues in products, harmful effects on human and animals along with environmental pollution. Most of the insect pests developed resistance against major insecticides. So, now ecofriendly approaches are essentially needed to minimize the loss and prevent huge use of chemicals to the crop. Biological controls should be integrated with other control measures because different methods are effective at different times and locations under varying conditions. Environment friendly pest management approaches aid in environmental protection because they frequently substitute chemical alternatives; alternatively, all available ecologically based management solutions are available and referred to as Integrated Pest Management (IPM). IPM is a pest management approach that employs all appropriate strategies to keep pest populations at levels below those that cause economic harm, taking into account

the surrounding environment and population dynamics. The approaches in the IPM are as follows

CULTURAL METHODS

Agronomic changes, while important for increased output, are also aimed at preventing pest infestations and its mass multiplication and dissemination by altering the crop microclimate.

INTERCROPPING

Growing two annual crops together, typically a leguminous crop like beans or a green manure crop in alternating rows with maize or another cereal crop or vegetable, is a frequent method in organic farming to diversify production and optimize land advantages. When intercropping, more care must be taken to avoid crop competition for light, nutrients, and water. This necessitates an understanding of the various configurations that support the growth of at least one of the crops.

MULCHING

In annual crops, covering the soil with dead plant material is a simple approach to manage weeds, insects and protect the soil. Most present cropping systems can benefit from this strategy.

CROP ROTATION

Crop rotation is the process of altering the sort of crops cultivated in a field from season to season or year to year. It's an important part of any organic cropping system because it's one of the fundamental processes for developing healthy soils, controlling pests and weeds, and maintaining soil organic matter.

SANITATION

It encompasses the removal or destruction of breeding refuges as well as pest overwintering. Before using seed material, farm yard manure, or other materials that may contain insect eggs or stages of development, they should be thoroughly screened. The destruction of alternate hosts reduces the growth of insect populations.

TILLAGE AND INTER-CULTIVATION

Ploughing and inter-cultivation create unfavorable circumstances for the proliferation of pests, diseases, and weeds. Harmful organisms' quiescent stages (pupae) will be exposed to dehydration or avian predation, while other stages may be mechanically injured or buried deep in the soil.

CULTIVAR SELECTION

The major sources of pest and disease epidemics and mass multiplication are cultivars with great production potential and quality but no resistance to pests and diseases. To fit different agro environments, a vast range of cultivars with pest and disease resistance have been produced. The use of such cultivars can help to significantly reduce losses.

TIME OF SOWING

The weather has an impact on plant development, as well as the growth and survival of pests and diseases, a major setback occurs when weather conditions coincide with vulnerable growth stages and the highest occurrence of pests and diseases. As a result, adjusting sowing dates is frequently used as an agronomic method to reduce crop losses.

PLANT POPULATION

Crop microclimate is influenced by plant population per unit area. Because of the dense plant canopy, there is a lot of humidity in the air, which is ideal for pest and disease reproduction. While the total plant population remains constant, inter and intra row plant populations can be modified to reduce the amount of humidity in the plant canopy.

MANURES AND FERTILIZERS

Excess nitrogen makes the crop more vulnerable to sucking and leaf-eating bugs. The key driver for heavy pest and disease incidence is higher nitrogen application rates than the optimum rate to hybrids without a corresponding rise in phosphorus and potassium. A well-balanced NPK greatly improves the crop's ability to withstand pests and illnesses.

WATER MANAGEMENT

Furrow irrigation, rather than sprinkler irrigation, can control anthracnose of beans, early blight, and charcoal rot of potatoes. Irrigation can minimize soil-dwelling pests by suffocating them or exposing them to the soil surface, where they can be eaten by birds. Potato scab can be reduced by irrigating the crop at the time of tuber formation.

HAND PICKING METHOD

If the crop is in a small region, this pest control strategy is useful. Fill a polythene bag with a tiny amount of kerosene and pick up the larvae during the evening hours. Pests can be controlled without the use of chemicals in this manner. When the pest population

is low, this should be done. Hand-picking larva: Weeds and wild grasses should be eradicated from field bunds and fields, as these are the bugs' favored egg-laying places.

BIRD PERCHES

IPM procedures benefit from the placement of 'T' shaped bird perches made of long dried twigs at a rate of 15-20 per acre. We can use bamboo or wooden poles or tree branches to create bird perches. These encourage birds to rest, and the larvae on the field are devoured by the resting birds. Predatory birds prefer to hunt for prey in fields since they may rest there. Predatory birds use bird perches to rest and hunt for prey, such as insect pests of cotton, peanuts, and cowpeas. In the field, erect one of them at regular intervals. Plant *Setaria* species in the field to provide live bird perches (foxtail cultivars). Predatory birds have been seen to be attracted to these plants.

PHEROMONE TRAPS

Pheromone traps use synthetically duplicated versions of insect pheromones, which are released compounds used by pests to interact with one another, to attract bugs and are commonly used to battle pests in vegetables. The sexual attractant secreted by some female insects is called pheromone. If this is used to bait a trap, the male insects will be drawn in and will be unable to escape. Alternatively, they provide information about insect numbers and, as a result, the optimal time to use pesticides. Commercial companies frequently prepare pheromone traps, which might be expensive for farmers. Pest damage can be reduced simply by using pheromone traps.

YELLOW STICKY TRAPS

Yellow sticky traps can be used to monitor and control pests. Aphids, Cabbage root maggots, Carrot rust fly, Cabbage white butterfly, Cucumber beetle, Onion fly, Thrips, and Whiteflies are all monitored and controlled using bright yellow sticky traps. Castor oil smeared yellow color empty tins or plates can also be utilized in the field for this purpose. These sticky traps are used to catch white flies. Every day, these are wiped clean and castor oil is reapplied. Aphids and leafhoppers can be trapped with yellow plastic cards that have been coated with glue. White flies should be monitored with yellow-orange plastic boards, whereas thrips should be monitored with blue cards.

BAIT TRAPS

Bait traps can be used to catch fruit flies. Half-filled poly ethylene bottles with small holes, for example, can be half-filled with water, a drop of detergent or soapy water, and some cattle urine, fruit flesh, or a small dead fish. These bottles are then hanged in trees for three days and checked.

LIGHT TRAPS

Armyworms, cutworms, stem borers, and other night flying insects can be caught using this. When light traps are put just after adult moths emerge but before they begin to lay eggs, they are more effective. The majority of the insects attracted are not pests. Furthermore, many insects that are drawn to the area around the light traps (from great distances) do not really fly into the trap. Instead, they stay close by, which increases the total number of insects in the region. Light traps, on the other hand, have the drawback of attracting a wide variety of insect species.

WATER TRAPS

They should be at least 6 cm deep, with a 250 to 500 cm2 surface area, and preferably round, with the water level about 2 cm below the rim. The addition of a few drops of detergent to the water ensures that thrips sink rather than drift to the edges and escape. Water should be replaced or added on a regular basis.

BIOLOGICAL METHODS

The use of biological pest management approaches has been steadily increasing in popularity. The two main components of integrated plant protection are cultural and biological techniques. The most often utilized bio-agents in pest and disease management can be divided into three groups, they are parasitoids, predators, and microbes.

PARASITOID

A parasite is a living entity that lives in or on another living organism and feeds on its nutrients, causing the host's growth, development, reproduction, or death. Parasitoid insects account for about ten percent of all insect species. Parasites and parasitoids are distinguished by the fact that parasites do not kill their hosts, whereas parasitoids do. Hymenoptera make up about 75% of the parasitoids, with Diptera, Strepsiptera, Neuroptera, Coleoptera, and Lepidoptera accounting for the remaining 25%.

EGG PARASITOIDS

Wasps that are too small to see with the naked eye can parasitize the eggs of larger insects like butterflies and moths. When compared to eggs that have not been parasitized, parasitized eggs are frequently darker in color. *Trichogramma* is a well-known egg parasitoid. *Trichogramma chilonis* (vegetables) @ 50,000/ha and Vegetables @ 6 weekly releases Large numbers of these parasitoids can be raised and released in a field. In the outdoors, egg parasitoids are common and serve a vital role in keeping pest numbers in check. Farmers should avoid using pesticides to protect these naturally occurring egg parasitoids.

LARVAL / PUPAL PARASITOIDS

Many little wasps prey on pests in their larval and pupal stages. The female wasp searches the crop for suitable larvae and lays one or more eggs in or on its host's body. Most parasitoids will exclusively parasitize one or a few closely related pest species. The percentage of parasitized larvae detected in a pest's larvae can be unexpectedly high at times. Parasites are commonly overlooked in the field due to their modest size. To identify if parasitoids are present, careful monitoring is required.

PREDATORS

These are insects that are larger than the host and feed on a variety of pests by predating on them from the outside. Several insect pests will be consumed during their life cycle, and they will play an important role in reducing pest populations in the field.

Predator	Prey
Insect predator Chrysopa	Aphids, mealy bugs and young caterpillars.
Chrysoperla sp	aphids, leaf hoppers etc.,
Ladybird beetle	Aphids and mealy bugs.
Spiders	Varied number and types of insects especially in rice ecosystem.

MICROBIAL ORGANISMS AS BIOCONTROL AGENTS

These are microorganisms that can cause diseases in insects, causing them to lose their appetite, suffer from a variety of physiological problems, and eventually die. Nematode pest management with biotic agents is another potential field that is garnering much-needed attention in the present organic farming landscape.

NUCLEAR POLYHEDROSES VIRUSES (NPV)

Viruses like NPV (nuclearpolyhedrosis virus) are efficient at controlling a variety of caterpillar pests. In insects, they induce the common tree top sickness. Due to O_2 depletion inside the insect system, the infected insect loses appetite, becomes restless, and reaches the apical portion of the plant. The diseased insect will eventually die by hanging itself in an inverted V shape on the plant's apical section. Insecticidal activity against lepidopteran insects in a variety of crops. *Helicoverpa armigera* is managed with Ha NPV, while *Spodoptera litura* is managed with Sl NPV.

BACILLUS THURINGENSIS

This bacteria is particularly efficient against a variety of insect pests in the Lepidoptera order. They spread disease, causing the insect to turn black and die.

METARHIZIUM ANISOPLIAE, BEAUVERIA BASSIANA AND VERTICILLIUM LECANII

Gram pod borer, tobacco caterpillar, and sucking pests like thrips, aphids, and mealy bugs are all targets for these. The fungi form hyphae inside the insect's system, causing mechanical congestion and the insect's death. Because of their manner of action, these organisms are ideal for organic farming. They can directly penetrate the exterior protective covering/layer in some circumstances. Fungus penetrates the insect body wall once it has attached to the host. The bug died as a result of severe fungal growth and fungal toxin poisoning. In root grubs and rhinocerous beetles, *Metarrhizum anisoplae* causes illness (green colour fungal growth). In addition to whitefly, thrips, aphids, and mealybugs, *Beauveria bassiana* is used to control whitefly, thrips, aphids, and mealybugs in vegetables and ornamentals. Several fungus species can be found in natural settings. Commercial preparations of *Verticillium lecanii,* an insect pathogenic fungus, are available for the control of aphids, thrips, and white fly in glasshouse settings. *Trichoderma*, *Pseudomonas* and *Bacillus* are significant biocontrol agents that can be grown on a farm to protect crops from a variety of soil and airborne plant infections. They also promote plant growth by improving germination, plant survival, and root and shoot growth. Specific or non-specific metabolites of microbial origin, lytic agents, enzymes, volatile chemicals, or other toxic substances mediate the antagonism mechanism of these species. Antibiosis is a condition in which metabolites are

secreted by plant subterranean portions, soil microorganisms, and other organisms. To multiply and live in their natural habitats, the beneficial microorganisms compete for space, minerals, and organic resources. Normally, *Trichoderma* applied as seed treatment at 4 g per kg seed and *Bacillus* or *Pseudomonas* applied at 10g per kg of seed. Soil application of above organisms can be done at 1 per acre of land.

BOTANICALS

Some weeds, such as Lantana, Notchi, Tulsi, and Adathoda, operate as natural pest repellents. Diamond back moth, heliothis, white flies, leafhoppers, and aphid infestation are all controlled by trees like pungam, wood apple, and anona, as well as their byproducts. Neem (*Azadirachta indica*), pungamia (*Pungamia glabra*), and mahua are the most often used botanicals (*Madhuca indica*). Rice cutworm, diamond back moth, rice BPH, rice GLH, tobacco caterpillar, aphids, and mites have all been reported to be resistant to neem seed kernel extract (2 to 5%).

NEEM

Neem, which comes from the arid tropical neem tree (*Azadiracta indica*), has numerous insecticidal chemicals. Azadiractin is the principal active element, which deters and kills a variety of caterpillar, thrips, and whitefly species. The neem solution can be made using both seeds and leaves. Although neem seeds have a higher concentration of neem oil, leaves are available all year. When exposed to direct sunshine, a neem solution loses its potency after around 8 hours of preparation. Under humid conditions or when the plants and insects are damp, apply neem in the evening, immediately after preparation.

GARLIC

Garlic is anti-feedant (it makes insects stop eating), insecticidal, nematicidal, and repellant. Garlic is said to be beneficial against a variety of insects at various phases of their life cycle (egg, larval, and adult). Ants, aphids, armyworms, diamondback moth, whitefly, wireworm, and termites are examples. Garlic is non-selective, has a broad-spectrum action, and can kill both harmful and helpful insects. As a result, it must be taken with caution.

CONCLUSION

Generally, the vegetables are prone for major attacks of insect pests. In order to minimize the incidence and minimize the usage of pesticides, the growers must take all available alternate methods to contain the incidence of pests there by the vegetables can be produced as pesticide free one.

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