

Research and Reviews: Journal of Ecology and Environmental Sciences

Knowing About Identify and Mode of Damage by Insect Pests Attacking Winter Vegetables and Their Management.

Muhammad Sarwar*.

Nuclear Institute for Agriculture & Biology (NIAB), Faisalabad, Punjab, Pakistan.

Review Article

Received: 17/07/2014
Revised: 15/08/2014
Accepted: 18/08/2014

*For Correspondence

Nuclear Institute for Agriculture & Biology (NIAB), Faisalabad, Punjab, Pakistan.

Keywords: Winter Vegetable, Insect Control, Pest Management, Pesticides, Pest Identification.

ABSTRACT

Vegetables are the important component of our daily diet and these provide a cheap source of proteins, vitamins and other elements essential for health and wellbeing of human. Most vegetables are available during the whole year, but the vegetables in winter season have a special attraction, and are juicy and freshest. Pest problem is one of the major constraints for achieving higher production in these crops. Among the insects observed, the frequently seen pests affecting the vegetables are several different species of order Lepidoptera, Homoptera, Hemiptera, Coleoptera, Orthoptera, Diptera, Thynanoptera and Acarina. The high levels of incidence of these pests cause so many changes in vegetable plants and also affect crop production. Most vegetable crops are subjected to pest damage, and seeds, roots, stems, leaves and fruit are all susceptible. Insect damage ranges from reduced plant vigor to plant death and heavy crop losses occur. Insects injury plants by chewing foliages, sucking juices, laying eggs and transmitting diseases. Managing and controlling insect pests is one of the keys to successful vegetable farming, and their identification is an essential first step. Therefore, an up to date knowledge about the incidence pattern of major insect pests and their identification on particular crop is a prerequisite for implementation of an effective and successful management tactics. This testimony describes the most common insect pests of winter vegetables and several control methods are combined in order to minimize damage. The growers need to quickly recognize insect problems, and practice early control to prevent their buildup and keep pests from getting out of control.

INTRODUCTION

The vegetables that are grown in the month of November till the month of April are included as the winter vegetables. These vegetables are light in weight, very much nutritious and delicious, and comprise beans, asparagus, peas, garlic, onion, lettuce, spinach, cabbage, potato, tomato, carrots, salads, beet, radish, cauliflower, mustard greens, fenugreek, gourd and bell pepper. These are the main components of our dishes during the winter months and are available in abundance. Most of winter vegetable plants are fully hardy and can cope well with cold winter weather, but if hard frosts threaten, then some fleece can be thrown across them to provide some extra protection [1-5]. These vegetables provide adequate quantities of vitamins, proteins, carbohydrates and minerals [6]. The nutritional content of vegetables varies considerably, though generally they contain little protein or fat, and varying proportions of vitamins such as vitamin A, vitamin K and vitamin B-6, pro-vitamins, dietary minerals and carbohydrates. Vegetables contain a great variety of other photo-chemicals, some of which have been claimed to have antioxidant, antibacterial, antifungal, antiviral and anticarcinogenic properties. Some vegetables also contain fiber that is important for gastrointestinal function [7].

The vegetable crops are attacked by number of insect pests in every season and these cause high damage to the production. Insects and pests generally attack vegetables because of their liking and to complete their life cycle. They damage and use every part of the plant and ultimate cause high economic loss to the farmers. Insects injury plants by chewing leaves, stems and roots, sucking juices, egg laying and transmitting diseases. Most vegetable crops are subjected to pest damage particularly seeds, roots, leaves, stems and fruits are all susceptible to damage effecting plant vigor resulting severe crop losses. Like other insects, the cucurbit fruit fly *Bactrocera cucurbitae*, is one of the most important pests of vegetables, and depending on the environmental conditions and susceptibility of the crop species, the extent of losses can vary between 30 to 100% [8-10]. Along with other insects, the vegetable crops are heavily attacked by aphids. Among fourteen different winter vegetables there are 14 species of aphids found to attack on all these species of plants, out of these only *Pentalonia nigronervosa* is found as monophagus species, while other are polyphagus. Among them *Aphis craccivora*, *A. corianderi*, *A. gossipii*, *Acyrthosiphon pisi*, *Bravicornyne brassicae*, *Lipaphis erysimi*, *Myzus persicae*, *Pentalonia nigronervosa*, have been observed as a regular pests of 12 plant species, while *A. gossipii*, *A. fabae*, *M. persicae*, are also serious pests of four plant species though sporadic in nature. *Macrosiphoniella sanborni*, *Hydaphis coriandri*, *P. nigronervosa*, *L. erysimi*, *Acyrthosiphon pisi*, *Macrosiphum rosaeformis*, are regular pests of six plant species. *Aphis craccivora*, *Uroleucon compositae*, *A. fabae*, *A. spiraeicola*, *A. gossypii*, *Rhopalosiphum nymphae* have been observed as sporadic pests of seven plant species [11]. These pests are a great concern for the farming community, as they could threaten the agricultural and horticultural industries by increasing the price of production and cost to the consumers. Correct identification of pest problems is the beginning of a successful integrated pest management (IPM) program. Further, pest identification is the most important step because miss-identification is a common cause of control failure. Knowing the correct pest, its life cycle and mode of damage are the key to select control measures that work effectively. A regular pest scouting can provide early warning of problems, allow the widest range of control options and bring favorable economic, ecological, and social consequences.

Insect pests damage to winter vegetables

Insect pests can damage vegetables in many ways. Pests such as tomato fruitworms, curculios and bugs feed on the fruit, causing direct damage. Other pests, such as loopers and worms feed on the leaves, while pests like aphids, whiteflies and mites suck sap from the plant, causing indirect damage. Even though the fruit is not damaged directly, the plant cannot efficiently produce fruit if too much loses of leaf area or sap occurs. Pests such as thrips and bean leaf beetles transmit plant diseases, and pests like corn armyworm, earworm and curculios cause damage by contaminating food with their frass and bodies. The following information covers the most common insect pests found in winter vegetables:-

Vegetable Insects - Piercing/ Sucking Mouthparts

These insects feed on plants by piercing the epidermis and damage vegetables by sucking plant juices from leaves, stems or roots. The true bugs, aphids, whiteflies and leafhoppers, all have beak-like mouthparts that are used to suck sap from plants. Some of these insects also produce toxic saliva, which they inject into plants. The best known example of plant injury caused by saliva injection is a condition called hopper burn caused by the potato leafhopper on potatoes. Many of these insects also transmit plant diseases.

Aphids (Aphididae: Homoptera)

Aphids often called plant lice are small, soft-bodied and sluggish insects with piercing-sucking mouth parts. They have many different species and color can vary from green to red, pink or black gray or yellow, depending on the species. Most species give birth to living young and the youngs build up very rapidly. They also lay eggs and there can be 15 to 20 generations per year of certain species. Aphids reproduce rapidly and can build to very high numbers quickly. All vegetables most commonly peas, beans, tomatoes, lettuce, turnips and broccoli plants are attacked. Aphids congregate in large numbers and therefore, may infest vegetables such as mustard greens and lettuce, and also may cause the plant to stunt. Aphids remove plant sap, kill developing plant cells and they also carry many diseases. Heavy infestations can cause leaf curl, yellowing, poor growth and failure to set blooms. Aphids also excrete large amounts of undigested plant sap. This sticky honeydew builds up on leaves, where it supports the growth of sooty mold fungi. Although sooty mold does not invade plant tissue, the black crusty mat it produces on the surface of the leaf is unsightly and can reduce photosynthesis. Most species are responsible for disease transmission that is probably more important than actual feeding damage.

Thrips (Thripidae: Thysanoptera)

Thrips are tiny insects, adults are small slender and they vary in color from light to dark brown. Wings are narrow and fringed, giving them a feathery appearance. The males of some species are wingless. Eggs are thrust into plant tissues, and nymphs are active, light-colored and wingless insects. The mouthparts of adults and nymphs are similar and unusual, they are designed to rasp plant tissues then suck the juices. The last nymphal stage is spent in the soil. Adults and nymphs pass the winter on plant tissue and feed on plant leaves and fruit with punch- and-lap type mouthparts. Several species of thrips occur on most vegetables, but greatest damage occurs on melons, tomatoes and peppers. Thrips can also distort leaf growth especially on seedlings and cause fruit blemishes especially on tomatoes and peppers. Damage appears as white flecks or streaks on leaves. Thrips infestations tend to be especially heavy in dry springs, but the most severe damage usually occurs in hot and dry years. One species, the western flower thrips, is the main carrier of tomato spotted wilt virus.

Whiteflies (Aleyrodidae: Homoptera)

Whiteflies are not true flies as they are relatives of mealy bugs, scales and aphids. There are several species of whiteflies feeding on brassicas and other vegetables, and can be especially difficult to control. Two of the most important species are the greenhouse whitefly *Trialeurodes vaporariorum* and the sweet potato whitefly *Bemisia tabaci*. Adult whiteflies are approximately equal to or less than the size of aphids and have white moth-like wings. They have a white, waxy coating and hold their wings parallel to the leaf surface. The eggs are laid on the undersides of leaves. They are cone-shaped and range in color depending on species from dark gray to burnt orange. Immature whiteflies are white, flat and oval shaped immobile nymph and they feed on the undersides of leaves. They have no legs and can be mistaken for scale insects at certain times. Both adults and immatures have piercing-sucking mouthparts and cause damage by removing plant sap, producing honeydew (a sugary liquid) and transmitting diseases. Both the nymphs and adults fly cause physical damage to the host plants, and attack the leaves, buds and stems sucking the plant juice. Without control measure, the infested plants turn yellow, growth become stunted and ultimately die. Some species of whiteflies can become serious pests of certain vegetable crops or greenhouse plants and when a heavily infested plant is disturbed, white clouds of winged adults fly into the air.

Leaf hopper (Cicadellidae: Homoptera)

Adults are pale green, wedge-shaped, and adults and nymphs both suck plant juices. Eggs inserted into plant tissues produce green nymphs that resemble adults but are smaller and wingless. At least three generations of this pest occur each year. This insect feeds on many different host plants including beans and potatoes. Saliva injected by this pest into potato plants causes a deadening and up curling of the tissues known as hopper burn. Sap feeding on beans causes leaves to stunt, crinkle and curl downward. The potato leafhopper is one of several leafhopper species found on vegetables. Potato leafhoppers feed by sucking juices from the potato plant. The first signs of leafhopper feeding are a subtle paling of veins and a curling of leaflets. Continued feeding causes a characteristic triangular yellowing or browning of the leaf tip known as hopper burn, in which potato foliage becomes curl and yellow. Injured plants usually are stunted and yields are reduced. Leafhoppers cause the greatest amount of damage when tubers are filling.

Bugs (Coreidae: Hemiptera)

Adults are bright green in color and nymphs are smaller, black and white or black and red. Bugs are characterized by sucking mouthparts that originate from the tips of their heads. They use their needle-like mouthparts to pierce the plant and sucking up plant juices. Their life cycle stages include the egg, adult-like nymphs and winged adults. Green vegetable bug attacks beans, tomatoes and potatoes, and is most active in hot weather. Bugs feed on flower buds and seed pods resulting in premature flower drop, seed damage and distorted development. In tomatoes, damage on green fruit appears as dark pinpricks, surrounded by a light discolored area that turns yellow or remains light green on ripe fruit. Fissures below the surface turn corky. Green vegetable bugs are rarely a problem for vegetable growers.

Two-spotted spider mites *Tetranychus urticae* (Tetranychidae: Acarina)

The two-spotted spider mite *T. urticae* has two forms, a green form with a dark spot on each side and the more common is a reddish form. Some species of mites may be yellow and all mites are very tiny and almost microscopic. Adult mites lay eggs on undersides of leaf and spin webs beneath which eggs

hatch and mites feed. Two-spotted spider mites usually occur in hot dry conditions and reproduce rapidly during such weather. It is more severe in dusty road side locations and has multiple generations on undersurface of leaf. Mites pierce leaf tissue and suck sap in the larval, nymphal and adult stages. Plants attacked begin to lose color, fading from green to yellow and eventually turn red. Heavy infestation may kill some plants and heavy webbing may appear on certain plants. Damage results by adults feeding in large numbers on leaf surface causing silvery appearance. Lower surface of attacked plant is often covered with webbing. Various plants are attacked including tomatoes, beans, corn, peas and various cucurbits. Heavily stippled leaves may wither at the edges, turn brown and fall off to ground. It is a late season pest and can be flared up by pyrethroid uses.

Vegetable Insects- Chewing Mouthparts

Chewing insects take their food by chewing off external plant parts. The caterpillars, the larval stage of moths and butterflies, damage both the foliage and fruit of a number of vegetables. These insects chew holes in foliage and fruit, and leave degrading excrement and silk on plants. Adult moths and butterflies, on the other hand have mouthparts designed for siphoning and are unable to damage plants, may or may not feed in the same way and on the same plants as larvae. Beetles have also chewing mouthparts and like many grubs (beetle larvae), are capable of causing great damage to vegetables. Adult beetles are usually hard-bodied insects with thick forewings and their young are grubs, borers or wireworms. Often adults feed on different host plants than do larvae, although both stages may be destructive to vegetables.

Leaf miners (Agromyzidae: Diptera)

Adult leaf miners are small, dark-colored gray to shiny black with yellow markings flies. Small, white eggs deposited in leaves produce white or yellow maggots that tunnel through the leaves. The larvae are small, peg-shaped, legless maggots that feed between the upper and lower surface of leaves, creating winding tunnels or mines. The mines, which are very narrow when the larva first hatches, become wider as the larva grows, finally forming a blotch. The leaves of a plant that is attacked by vegetable leaf miners are weakened, while the mines serve as sites for disease and decay. Low numbers of mines cause no real damage to the plant, but heavy, persistent infestations can reduce leaf area, resulting in reduced plant vigor. Small maggots of tiny flies hatch from eggs and live in leaves and their serious infestations may occur most commonly on tomatoes. Heavy infestations occasionally occur on beans or peas. The mature larvae exit the leaf and fall to the ground to pupate. The pupal stage is spent in the soil and in this stage the pest overwinters.

Vegetable weevil *Listroderes difficilis* (Curculionidae: Coleoptera)

The adult is stout-bodied dull grayish-brown weevil with short and stout snout and usually have a distinct, light-colored "V" on the back, and can rarely fly. The legless larvae are greenish-yellow with a slug-like shape and are found crawling about on leaves and in plant crowns. Both the larvae and adults attack vegetables, particularly potatoes, tomatoes, brassicas, and root crops such as carrots and turnips as well as other vegetables where it can cause considerable damage. Both adults and larvae are leaf-feeders, but they also damage stems and roots. Newly transplanted tomatoes and other seedlings sometimes experience heavy damage, especially when are in an area where turnips, mustard or other winter brassica crops are recently growing. They are usually nocturnal feeders and their damage to vegetable crops sometimes is regarded as rare. The pupation of weevil occurs in the soil.

Beetles (Chrysomelidae: Coleoptera)

Beetles are a diverse group of insects characterized by adults with hardened wings and grub-like larvae that are sometimes mistaken for caterpillars. Some beetle larvae live underground like black beetle (*Heteronychus arator*), their adults are glossy black and eggs laid hatch into larvae known as white grubs or curl grubs. The beetles attack a range of vegetable crops, but can be a particular problem in potatoes. The beetles attack plants, usually at ground level or just beneath the soil surface. They damage seedlings and young plants more than the mature plants. Adults' vegetable beetle (*Gonocephalum elderi*) or false wireworm is oval and flattened in shape. They are usually a dull gray, but sometimes appear brown or almost black. They often have soil or sand stuck to their backs. The larvae are brown and worm-like, but have a hard and shiny skin, with three pairs of legs at the front.

Cutworm caterpillars (Noctuidae: Lepidoptera)

There are several species of cutworms and many of which overwinter in the soil as partially grown larvae. They have a very wide host range and can damage almost all vegetable crops, weedy vegetation, and young seedlings are especially vulnerable. The caterpillars are brown or black, herring-boned and hairless. They can be found in the soil surrounding the plant and curl up from mouth to tail when disturbed. The caterpillar pupates in the soil and emerges as a medium-sized, grey-bodied moth with dark wings. Cutworms may be active throughout the year, but the autumn and more especially the spring generations, cause the most damage, attack young transplants and newly emerged seedlings. Cutworm caterpillars eat plant's stem, and sometimes cut the stem of young transplants and newly emerged seedlings. Because transplants are more costly and are planted at lower densities, the potential for serious damage is higher for the transplants than for direct seeded plants. As plants grow larger, they become less susceptible to cutworm injury.

Armyworms (Noctuidae: Lepidoptera)

Several species of armyworms occur and attack on the vegetables, and these include beet armyworms, yellowstriped armyworms, Southern armyworms and fall armyworms. Armyworm moths lay their eggs in large clusters, so, large numbers of caterpillars can often be seen on one plant or in a small area of the vegetation. Armyworms are robust caterpillars except for the fall armyworm; the bodies of these caterpillars are smooth and hairless. The fall armyworm appears slick bodied, but close examination reveals a few stiff hairs on the body. Armyworms are mainly leaf-feeders, but some species occasionally damage fruit. Fall armyworms are particularly a problem on late-planted corn, causing damage by feeding in the whorls of pre-tasseling plants or by chewing into the sides of ears on more mature plants. Yellowstriped armyworms are present in early spring and often cause minor defoliation damage to seedling tomatoes, beans and other plants. Occasionally, yellow striped armyworm larvae also feed directly on fruit. Cluster caterpillars (*Spodoptera littura*) chew holes in leaves. Older caterpillars also attack flowers and pods. Young caterpillars are smooth skinned with a pattern of red, yellow, and green lines. When disturbed, the caterpillar curls into a tight spiral with the head protected in the center. They attack a range of crops including lettuce and tomato.

Tomato fruitworms *Heliothis (Helicoverpa punctigera/ armigera)* (Noctuidae: Lepidoptera)

These caterpillars damage and ruin a wide range of crops, and are a particularly important pest of corn, tomato, lettuce and occasionally other vegetables. They also from time to time occur in other vegetables, such as beans and peas, but seldom in high numbers, however are especially damaging to tomatoes. The night-flying *Heliothis* moths are light brown with one somewhat indistinct spot in the center of each forewing. They lay small, round eggs individually on the silks of corn or on the bloom clusters of tomatoes. Newly deposited eggs are white but become darker as they mature. The robust caterpillars vary from green or light yellow to brown or black color. Caterpillars bore into fruits, in corn the damage is usually restricted to the first one or two inches of kernels at the tip of the ear, but when the larvae bore into tomatoes the entire fruit is usually lost.

Cabbageworm *Pieris rapae* (Pieridae: Lepidoptera)

The adults are common white butterfly with one or two black spots on each wing that are commonly seen flying around plants during the day. The undersides of the forewings are similar to upper surfaces, except for the absence of the black wing tips. The undersides of the hind wings are plain pale yellow. Eggs are yellow and oblong, and are laid singly on both upper and lower sides of leaves of a food plant. Caterpillars are velvety-green and are decorated with three indistinct pale yellow or gold stripes, one along the back and one of yellow spots on each side. It normally sits on the upper surfaces of leaves in broad daylight and moves sluggishly when prodded. This caterpillar is similar in color to the leaves of many of its food plants that are presumably an effective camouflage. It attaches itself at both ends of the body with silken pads, and also puts a loop of silk around its middle. When the caterpillar is fully grown, it creeps off for searching a sheltered crevice in which to pupate. It usually crawls upwards for searching and if its search is unrewarded then may pupate on an exposed wall and then emerges as adult butterfly within 3 weeks. It seems to need food plants that contain mustard oil, so it feeds on most species of the family Brassicaceae. The plants attacked include cabbage, cauliflower, broccoli, brussels sprouts, radish, collard, mustard and kale. The caterpillars eat large irregular holes in leaves and into heads, causing stunted growth, failure of heads formation or making produce unusable.

Cabbage looper *Trichoplusia ni* (Noctuidae: Lepidoptera)

Several species of loopers occur in the winter vegetables, but the cabbage looper is the most common. The adults are nocturnal or night-flying moths and they have mottled grayish brown wings with a small silvery white figure-eight-shaped spot in the middle of each front wing. Eggs laid are easily seen on the leaves. They are creamy white, aspirin-shaped and about the size of a pin head, and are most often laid on the undersides of the lower leaves. The caterpillars are pale green with narrow white lines running down each side. Loopers have fewer prolegs than other caterpillars, having no legs in their middle section, and bear three legs behind the head and three legs at the tip of the abdomen. They move in a distinct looping action or crawls in a looping fashion. These caterpillars often rest by grasping the leaf with the prolegs, located near the rear of the body, and holding the head and true legs away from the leaf surface. The plants attacked are cabbage, cauliflower, broccoli, brussels sprouts, radish, collard, mustard, kale, lettuce, celery, spinach, beet, pea, potato and tomato, but they can also damage other vegetables. Damage is mostly due to defoliation and from fecal contamination. Newly hatched caterpillars often feed on the bottom side of the leaf, leaving the transparent upper epidermis intact. This creates a windowpane effect and these windowpane areas can be an early warning of looper infestations. These should be controlled when they are small because large loopers are difficult to control.

Diamondback Moth *Plutella xylostella* (Plutellidae: Lepidoptera)

Moths are light brown marked with white markings along the back and overwinter in protected locations as adults. When the moths are at rest, their folded wings show a pattern of three white diamonds (has white, diamond-shaped markings along the back) with a tan border down the middle of the back. The hind wings are paler and have a fringe of hair on the rear margin. Eggs are laid near leaf veins on leaf surfaces, and are creamy white and tiny. Larvae are greenish-yellow with black hair and they wriggle actively when disturbed and drop from the plant on silken threads. Mature caterpillars are light green and tapered at both ends. The caterpillars tend to be very active when handled, often wiggling vigorously when touched or flipping off the plant. Diamondback caterpillars are much smaller than both imported cabbageworms and cabbage loopers. The small, silken cocoons are attached to the undersides of leaves or in the heads of broccoli or cauliflower. Larvae pupate inside a lacy cocoon attached to the leaf of the host plant. Larvae feed for a time after hatching as leaf miners on vegetable, but as larvae grow, they begin feeding on the external portion of leaves and buds. Larvae tunnel in leaves and patches on underside of leaves are eaten, leaving only transparent film on top. Feeding holes do not penetrate the entire leaf. The plants attacked are cabbage, cauliflower, broccoli, brussels sprouts, radish, collard, mustard and kale. Initially, diamondback caterpillars feed inside the leaves, but after a few days move to the outside of the leaves to feed. They often eat all the leaf tissue except the upper layer, resulting in a characteristic windowpane looking. Also, the larvae eat many small holes on underside of leaves, giving plant a shot-hole appearance, or sometimes feeding does not go entirely through the leaf. Heavy infestations can cause severe defoliation. Plants that are severely defoliated in the seedling stage may fail to form proper heads. Moths overwinter in debris of collards, cabbage, cauliflower and related crops.

Grasshopper (Acrididae: Orthoptera)

Many species of grasshopper damage vegetables, frequently these pests migrate from dried up vegetation to more succulent vegetables. Adults have front wings that are longer than the body and are held roof-like over the insect. Hind wings are softer and are folded fanlike beneath the forewings when the insect is at rest. The hind legs are long and adapted for jumping. Size varies according to species. Nymphs resemble adults in habits and appearance but are smaller and wingless. Adults and nymphs cause damage by feeding on foliage and most species overwinter as eggs, which are laid in packets in the soil.

Mole cricket (Gryllotalpidae: Orthoptera)

Mole cricket adults are velvety brown, have short forewings and long membranous hind wings. The front legs are rake-like and developed for digging, and somewhat resemble to the forepaws of a mole. Hind legs are enlarged. Eggs are laid in an underground chamber. Nymphs are small, wingless versions of adults, and both nymphs and adults overwinter. This insect burrows in soil, causing major damage by uprooting young plants. The insect is capable of severely damaging the roots and tubers of potatoes. The attack and damage to vegetable foliage may also occur.

Winter vegetable's insect pests control

Insect control is important to keep the pests from spreading to other crops and it may also help to reduce the incidence of disease by killing insect vectors. Two or more methods of pest control are usually much effective than a single method. It is essential to have a good plan for a successful insect pests management of winter vegetables. Each vegetable have different insect pests control requirements, but many options are common ^[12]. The following are some of most important methods to control and prevent pest damage for keeping in mind before a pest control plan is made:-

Resistant plant varieties

Some vegetable varieties may be less preferred to insect pests, or may possess certain physical and chemical properties which discourage insect feeding or egg-laying, and may be able to support large insect populations without suffering appreciable damage. Actually, these are distinguishing plant varieties which exhibit less insect damage when compared to other varieties under similar growing and pest population conditions. Always use available plant species or varieties which are resistant or tolerant to insect activity.

Cultural control

Numerous cultural practices can be used to reduce the actual damage of plants caused by insects, for instance, plowing and cultivating exposes soil insects to adverse weather conditions, birds and other predators. In addition, deep plowing can bury some insects and prevent their emergence. Crop rotation can be effective against insects that develop on a narrow range of food plants and also against insects with short migration ranges. By moving the areas where tomatoes, potatoes and other vegetables are grown around each year, can minimize the spread of disease, and the cycle of pest and disease organisms is broken. Mixed planting in vegetables can encourage predatory species, for example, buckwheat attracts hoverflies. These beneficial insects prey on aphids, leafhoppers and mealy bugs. Proper use of fertilizers and water can induce healthy plant growth and increase the capability of plants to tolerate insect damage.

Mechanical control

Preventive devices, for examples use of spun bound polyester row covers to prevent insect egg laying, mesh covers for tomatoes and other plants to keep out large insects and birds, and aluminum foil mulch to repel aphids are recommended.

Biological control

Generally, biological control is the direct or indirect use of parasites, predators or pathogens (bacteria, viruses, fungi, protozoans) to hold pest insect populations at low levels to avoid economic losses. Biological control methods fall into three categories, 1. Introduction of natural enemies which are not native to the area (these enemies must then establish and perpetuate themselves). 2. Enlarging existing populations of natural enemies by collecting, rearing and then releasing them back into the environment. 3. Conservation of beneficial organisms by such means as the judicious use of pesticides and the maintenance of alternate host insects, so parasites and predators can continue to develop. The list of some of the more popular biocontrol agents includes *Bacillus thuringiensis* (this bacterial insecticide provides effective control of the larvae of several moths and butterflies), *Nosema locustae* (spore Protozoan used to control grasshoppers), and *Trichogramma* wasp (attack the eggs of many pest species, including cutworms, armyworms, fruitworms and many moth and butterfly eggs deposited in field crops). Green lacewings *Chrysopa* larvae known as aphid lions, prey on many vegetable pests including aphids, spider mites, leafhoppers, thrips, moth eggs and small larvae. Praying mantis captures and kills grasshoppers, crickets, bees, wasps and flies. For lady beetles, aphids are the preferred hosts, but can also eat mealy bugs, spider mites and certain other soft bodied pests and eggs. Animal predators such as frogs for caterpillars, predatory wasps for small insects, and ducks can be used for snails and slugs.

Organic insecticides for vegetable protection

The pesticides residue concentrations in vegetables of different season have show that the winter vegetables are the most contaminated followed by summer and rainy vegetables. The concentration of the various pesticides are well below the established tolerances but continuous consumption of such

vegetables even with moderate contamination level can accumulate in the receptor's of body and may prove fatal for human population in the long term. The analysis of health risk estimates indicated that chlorpyrifos and malathion did not poses a direct hazard ^[13]. With increasing affluence, there are increasing concerns about pesticide usage and perceived environmental effects. This has accelerated the shift to softer products and technologies. Some vegetables can be protected from insects infestation by spraying 4% leaf extracts of neem. Plant extract emulsion can be prepared by soaking 400 g of leaf powder (leaves dried under shade and powdered) in one liter of water for 24 hours and filter through muslin cloth. Dissolve 400 g of ordinary bar soap shavings in 9 litres of water. Pour this soap solution to the plant extract and mix thoroughly. This forms 4% emulsion of plant extract.

Insecticides for vegetable protection

Some of the more common insecticides labeled for use in the vegetables are Acetamiprid (effective against whiteflies, aphids and other pests), Imidacloprid (soil-applied systemic insecticide that is especially useful against whiteflies, aphids and beetles), Spinosad (microbial insecticide that is very effective against most caterpillar pests), Carbaryl (useful against many beetles), and Malathion (especially useful to control aphids, bugs and certain beetles). Pyrethroids is a group of relatively new synthetic insecticides modeled after the botanical pyrethrum molecule, pyrethroid insecticides are Permethrin (effective against many beetles, bugs, and caterpillars), Bifenthrin (triggers outbreaks of spider mites or aphids), Lambda cyhalothrin (effective against a number of different insect pests), and Cyfluthrin (effective against several different insect pests). Integrated pest management is a method of pest control where many strategies are used, for example, options for insect pests control are transgenic plants, baits and baiting systems, population disruption, entomopathogens, natural enemies, cultural control and host plant resistance. Moreover, the impact of most insect pests can be easily minimized by practicing a little prevention, tolerance and management tactics.

REFERENCES

1. Sarwar M. Frequency of Insect and mite Fauna in Chilies *Capsicum annum* L., Onion *Allium cepa* L. and Garlic *Allium sativum* L. Cultivated Areas, and their Integrated Management. Int J Agron Plant Prod. 2012;3(5): 173-178.
2. Sarwar M. Insect pests management stratagem for carrot production. Econ Rev. 2005;4 XXXVI (4): 28-30.
3. Sarwar M. Improving insets controlling on radish crop. Econ Rev. 2005; 4 XXXVI (4): 31-33.
4. Sarwar M. How to control Insects of Cauliflower (*Brassica oleracea*) using an integrated strategy. Econ Rev. 2004; 10, XXXV (3-4): 14-17.
5. Sarwar M. Some observations on the management of turnip insect pests. Econ Rev. 2004; 11/12, XXXV (4): 48-50.
6. Johnson GI, WK Katinka, MH Wu. The Vegetable Industry in Tropical Asia: India. An Overview of Production and Trade. AVRDC- The World Vegetable Center, Shanhua, Tainan, Taiwan. 2008; 74 p.
7. Deeplata S, DV Rao. A field study of pest of cauliflower, cabbage and okra in some areas of Jaipur. Int J Life Sc Bt Pharm Res. 2012; 1 (2): 122-127.
8. Dhillon MK, JS Naresh, R Singh, NK Sharma. Evaluation of bitter gourd (*Momordica charantia* L.) genotypes for resistance to melon fruit fly, *Bactrocera cucurbitae*. Indian J PI Prot. 2005; 33 (1): 55-59.
9. Sapkota R, KC Dahal, RB Thapa. Damage assessment and management of cucurbit fruit files in spring-summer squash. J Ento Nematol. 2010; 2 (1): 7-12.
10. Sarwar M, M Hamed, B Rasool, M Yousaf and M Hussain. Host Preference and Performance of Fruit Flies *Bactrocera zonata* (Saunders) and *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) For Various Fruits and Vegetables. International Journal of Scientific Research in Environmental Sciences. 2013; 1 (8): 188-194.
11. Rafi U, MK Usmani, MS Akhtar. Aphids of ornamental plants and winter vegetables and their aphidiine parasitoids (Hymenoptera: Braconidae) in Aligarh region, Uttar Pradesh. J Threatened Taxa. 2010; 2 (9): 1162-1164.
12. Sattar M, M Sarwar, G Hussain. Impact of pH, Nitrogen and Protein Contents in Some Cucurbits on the Population Build-Up of Whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae). Pakistan J Zool. 2005; 37 (4): 275-279.
13. Bhanti M, A Taneja. Contamination of vegetables of different seasons with organophosphorous pesticides and related health risk assessment in northern India. Chemosphere. 2007; 69 (1): 63-8.