



# **Pest Complex of Cole crops and their Management**

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Cover page Photo:

Front cover: A farmer is harvesting the matured cabbage from cabbage field

Back cover: Unsafe method of spraying of pesticide on cauliflower crop

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# Pest complex of cole crops and their management

Uma Shankar, Deepak Kumar, S. K. Singh and Saurav Gupta

## INTRODUCTION

The state of Jammu & Kashmir has varied habitats and climatic conditions which have encouraged the cultivation of a number of vegetable and other commercial crops. This state is known for quality fruits and vegetables production from subtropical, intermediate and temperate areas. Jammu in particular is known for intensive vegetable growing areas and produces various kinds of vegetables round the year. Vegetables are the prime source of vitamins and minerals and also the important source of income generation among the farming communities. The commercial cultivation of vegetables is three to four times more remunerative than the cereals and fetch not only the higher income but also provides employment opportunity to the family labour.

Among the various temperate vegetables produced in Jammu and Kashmir, the vegetables viz., cauliflower, cabbage, broccoli, Knol-khol, tomato and pea are the important ones that add higher revenue to the state. However, the production of these vegetables compared to the other states of the country is meager. The major constraints in the production of these vegetable crops are the damages caused by various insect pests and diseases which not only result in the low production of vegetables but also drastically impair the quality which render them unfit for human consumption and reducing the marketable yield.

Various insect pests have been observed to attack cole vegetable crops, in which, the most important ones are lepidopteran insect pests complexes i.e., cabbage butterfly (*Pieris brassicae* and *P. rapae* Linnaeus), tobacco caterpillar (*Spodoptera litura* Fabricius and *S. exigua*), cabbage semilooper (*Trichoplusia ni* Fabricius), cabbage head borer (*Hellula undalis* Fabricius and *Helicoverpa armigera* Hubner), diamondback moth (*Plutella xylostella* Linnaeus) and Tussock moth (*Orgyia* spp.). Coleopteran insects comprises flea beetles (*Phyllotreta cruciferae* and *Monolepta signata*), dipteran insect like cabbage leaf miner (*Liriomyza* spp.), Cabbage maggot (*Delia antiqua*) and fruit fly (*Bactrocera* spp.), homopteran insects such as cabbage aphids (*Brassicorhynchus brassicae* L.), crucifer aphids (*Lipaphis erysimi*) and green peach aphid (*Myzus persicae* Sulzer), hemipterans like painted bug (*Bagrada cruciferarum*), Grasshoppers (*Schistocera gregaria*), katygids (*Microcentrum* spp.) are found attacking the crops in various stages and their extent of damage is also varies from season to season. These insect pest render 50 to 80 per cent losses under severe infestation and causing drastic reduction in the marketable yields. Besides these insect pests, various fungal and

bacterial diseases like damping off of seedlings, black rot, alternaria leaf spots, soft/white rot, black leg and yellowings of cole crops also prevail in the field conditions of Jammu province and together with insect pests causes even 100 per cent damage to the crops.

Common Name	Scientific Name	Order & Family	Status
<b>Lepidopteran insect pest complex</b>			
Cabbage caterpillar (large & small)	<i>Pieris brassicae</i> , <i>Pieris rapae</i>	Lepidoptera: Pieridae	Major Minor
Tobacco caterpillar	<i>Spodoptera litura</i> , <i>S. exigua</i>	Lepidoptera: Noctuidae	Major Minor
Cabbage semilooper	<i>Trichoplusia ni</i>	Lepidoptera: Noctuidae	Major
Cabbage head borer	<i>Hellula undalis</i>	Lepidoptera: Pyralidae	Major
Cabbage borer	<i>Helicoverpa armigera</i>	Lepidoptera: Noctuidae	Major
Diamondback moth	<i>Plutella xylostella</i>	Lepidoptera: Plutellidae	Major
Tussock moth	<i>Orgyia</i> spp.	Lepidoptera: Lymantridae	Minor
<b>Coleopteran insects</b>			
Flea beetles	<i>Phyllotreta cruciferae</i> <i>Monolepta signata</i>	Coleoptera: Chrysomelidae Coleoptera: Chrysomelidae	Minor Minor
<b>Dipteran insects</b>			
Cabbage maggot	<i>Delia platura</i>	Diptera: Anthomyiidae	Minor
Cabbage leaf miner	<i>Liriomyza trifolii</i>	Diptera: Agromyzidae	Minor
Fruit fly	<i>Bactrocera tau</i>	Diptera: Tephritidae	Major
<b>Homopteran insects</b>			
Aphids	<i>Brassicorhynchus brassicae</i> <i>Myzus persicae</i> <i>Lipaphis erysimi</i>	Homoptera: Aphididae	Major
<b>Hemipteran insects</b>			
Painted bug	<i>Bagrada cruciferarum</i>	Hemiptera: Pentatomidae	Minor
Spined bug	<i>Cletus</i> spp.	Hemiptera: Coreidae	Minor
<b>Orthropteran insects</b>			
Grasshoppers	<i>Chistocera gregaria</i>	Oethroptera: Acrididae	Minor
Katygids	<i>Microcentum retinerve</i>	Oethroptera: Tettigonidae	Minor

Farmers quite often apply insecticides and fungicides to combat these pests on temperate vegetables. Sometimes, they apply those pest control chemicals that are not at all recommended and often uses heavy amounts of chemical pesticides by increasing the doses. Such type of indiscriminate use of chemicals not only triggered the residues problems on food but also disrupts the ecological balance of Agri-Horti-Ecosystem. Simultaneously, it is more dangerous in cole vegetables crops because most of them are being eaten raw or used for salad purposes.

Integrated pest management helps the farmers to reduce the dependence on chemical pesticides and safe guarding the environmental pollution and maintains ecological balance. IPM includes all possible and available methods like cultural, physical, mechanical, biological control, host plant resistance, and all conventional non-chemical and eco-friendly chemical methods of insect pest control. It is ever evolving , dynamic and science based decision making process that identifies and reduces risk from insect pest and diseases and pest management related strategies. It co-ordinates the use of pest biology, environmental ecology, nature of damage by pest and available technology to prevent pest damage by the most economic means while posing least possible risk to human beings and on the environmental resources. Thus, management of insect pest and diseases is a necessity in commercial as well as in kitchen garden vegetables production in Jammu.

The objective of this bulletin is to provide the practical means of identification and managing cole crops insect pest and diseases to the vegetable growers of Jammu region.

## **Insect pests of cole crops recorded in Jammu region**

### **Insect pests of cole crops**

#### **1. Cabbage butterfly (*Pieris brassicae* and *P. rapae*)**

It is also known as imported cabbage worm. Two species of cabbage butterflies i.e. large butterfly, *Pieris brassicae* and small butterfly, *P. rapae* have been recorded and found damaging the cole crops in Jammu province. They are serious threats to the crops grown for seed purpose especially in hills as well as in plain areas of Jammu, also.

#### **Biology:**

Adults are small to large sized butterflies, pale white with black markings. Female butterflies having two black circular dots on the dorsal side of each forewings. After mating, female butterflies lay about 100-150 conical, yellowish eggs in clusters on lower or upper side of the leaf. The eggs hatch in 3-15 days depending upon the environmental temperature. Just after hatching, the caterpillars feed gregariously on leaves in early stages. They pass through five larval instars and become full grown in 2-3 weeks from October to April- May except in cool winter months during November-January. They completely skeletonize the leaves leaving only mid ribs. Due to complete loss of photosynthetic area crops failed to produce the economic yields.



**Eggs**



**Neonate larva**



**Skeletonized leaves**



**Adult *Pieris***

**Management:**

- Hand picking and mechanical destruction of caterpillars during early stage insect pest attack is beneficial.
- *Cotesia glomeratus* are recorded as a potential parasitoids against cabbage caterpillar larva.
- *Phryxe vulgaris* (dipteran fly) are also observed abundantly in cole crops fields to parasitize the caterpillars.
- Foliar spray of Bacterial (Bt) formulations @ 500 g/ ha along with sticker (0.5 ml/lit of water) is found promising to manage all lepidopteran insect pests.
- Need based application of cypermethrin @ 1 ml per lit or malathion @ 2ml per lit of water at evening hours may be promising in case of severe infestation.

**2. Tobacco caterpillar (*Spodoptera litura* and *S. exigua*)**

It has a wide host range and economic insect pest of cole crops but it is usually kept under controls by targeted to lepidopteran pests of cole crop. Its population rises in the spring coincides with abundance of other vegetable crops production in Jammu. Many weeds plant also serve as hosts, including bathua, choulai and Parthenium. The young larvae feed gregariously and scrape the leaves and later on it may completely defoliate the leaves. Since adults can readily invade a field from nearby crops or weeds, monitoring the crop twice a week for *Spodoptera* damage and their presence is recommended.

**Biology:**

The insect is active during the entire year and females can lay up to 600 eggs each, usually in groups of about 100. Eggs are laid on the underside of lower leaves and are covered with fuzzy, white scales. Under warm conditions, eggs hatch within two to three days. The larvae feed from one to three weeks, in groups at younger stage and scattered on the plants when larger. When they attain full-growth, larvae pupate in the soil. The adult emerges within about a week from pupa in normal condition.



Egg mass



Young larvae



Defoliated leaves

Adult *Spodoptera***Management:**

- Summer ploughing is beneficial to expose the hibernating pupae to natural enemies.
- Hand picking and mechanical destruction of egg masses, caterpillars and spraying

of NSKE 5% during early stage may proved beneficial.

- Installation of pheromone traps @ 25 to 30 /ha may be the useful tool for early detection and also for mass trapping and destruction of insect pest.
- Spraying of Splt NPV @ 250 LE with gur or jaggary (10 g/lit) and sticker during evening hours may be the promising to control Spodoptera caterpillar.
- Foliar spray of Bt formulations @ 500 g/ ha is the good for controlling the caterpillars.
- Need based application of cypermethrin @ 1 ml per lit or malathion @ 2ml per lit of water can also be used in case of severe infestation.

### 3. Cabbage semilooper (*Trichoplusia ni*)

As the name indicates, caterpillars are pale green in colour and moved with remarkable loop movement. It is polyphagous insect and defoliates a wide variety of crops including cole crops. The insect remains active and found throughout the winter months and their peak populations are observed in September-October and again during February-March in Jammu province. Its larvae damage the crops by chewing irregular holes in leaves. The feeding damage and excrement left behind on heads by semilooper caterpillar make cabbage and cauliflower unmarketable.

#### Biology:

Eggs are deposited singly or in small clusters on lower leaf surface. Female moth can produce 300 to 600 eggs. After hatching the eggs, the larvae crawl to move on the lower leaf surface to feed. Two to four weeks after hatching, the mature larva forms a thin cocoon on the lower leaf surface, or in plant debris or soil. The pupal stage lasts for approximately two weeks. Total time required for development from egg to adult may vary from 22 days to 35 days.



Feeding holes



Magnified semilooper



Pupa



Adult semilooper

#### Management:

- Hand picking and mechanical destruction of caterpillars
- Tachinid fly, *Voria ruralis* is the larval parasitoids of semilooper larvae.
- Foliar spray of Bt formulations @ 500 g/ ha along with sticker (0.5 ml/lit of water) and need based application of cypermethrin @ 1 ml per lit or malathion @ 2ml per lit of water are effective to control the semilooper caterpillar.

### 4. Cabbage head borer (*Hellula undalis* and *Helicoverpa armigera*)

Cabbage head borer is seen sporadically but its attack coincides with the head/curd initiation stage and a single larvae is responsible to damage the entire head/curd. The

early instar may feed on the growing point, and bore inside the head and damaging the head and excrements which prevents head formation. When fully grown, larvae pupate inside the head, or on stems, or in soil. *Helicoverpa armigera* larvae have also been recorded at several places in Jammu region as head borer of cabbage. It may be due to absence of preferred host in winter months or some environmental and behavioural change.

### Biology:

The adult moth is slender, pale yellowish brown in colour having grey wavy lines on the forewings and hindwings. Female moth lays pinkish oval eggs singly or in groups on the under surface of leaves. Eggs hatch after 3-4 days and neonate larvae feed inside the cabbage by making tunnels. Later on, they feed on leaf surface and bore into the heads of cauliflower and cabbage. The infested plants show deformed heads and full of excrements and frass of larvae which may become unfit for consumption and marketing. The full grown larvae forms a cocoon inside the tunnel or among the leaves. The adults emergence may vary from 6-9 days and completed their life cycle in 15-25 days.



*Hellula* larva

Adult *Hellula*

*Helicoverpa* larva

Adult *Helicoverpa*

### Management:

- Monitoring and mechanical destruction of larvae at the time head /curd initiation may proved to be good.
- Bracon spp. are important larval parasitoid against head borer.
- Fungal formulations like *Beauveria bassiana* and entomopathogenic nematodes (EPN) may be beneficial to suppress the attack of head borer.
- Spraying of synthetic pyrethroids like cypermethrin, fenvalerate, deltamethrin @ 1 ml per lit of water is effective to control head borer.

### 5. Diamondback moth (*Plutella xylostella*)

Diamondback moth became the main and universal pest of cole crops and it remains one of the most serious problems for the intensive cole crops growing areas. Plants at all stages of growth may be attacked by this pest. In Jammu province, diamondback moth is recorded on late season cole crops and on crucifers i.e., from February to April-May.

### Biology:

The small and active moth lays its eggs on the lower surface of leaves singly or in

groups of two to three. Soon after hatching the eggs, larvae begin to feed by mining on the undersurface of the leaves and crop become completely skelotonized in case of severe infestation. The larval stage can range from ten days to a month, depending on temperature. The threshold temperature for DBM larval growth and developments are 10° C. The pupal stage is passed within a transparent, loose cocoon, which is usually attached to the underside of leaves. Within about one to two weeks of entering the pupal stage, the moths emerge.



Adult



Larval feeding



Pupae



Damaged plants

**Management:**

- Use of pheromone traps are useful in monitoring and detection of the DBM pest population in early stages.
- Practice of trap or intercropping of mustard, coriander and marigold with cole crops may reduce the DBM pest infestation.
- Release of *Cotesia plutellae*, natural bio-agent of DBM larvae is effective to suppress its population in field condition (1000 adults per release every 2 week interval up to harvest).
- Use of resistant varieties are also effective against DBM.
- Some safer insecticides and neem products are recorded to be effective against DBM.
- Spray cypermethrin @ 1ml, cartap hydrochloride @ 2ml, spinosad @ 1ml and Bt formulation @ 500 g/ha may be promising in controlling the DBM pest population.

**6. Tussock moth (*Orgyia* spp.)**

It is polyphagous pests on various crops and seen sporadically on cole crops. It has also been found defoliating the leaves of cole crops.



Tussock moth

**Management:**

As suggested for cabbage caterpillars

**7. Flea beetles (*Phyllotreta cruciferae* and *Monolepta signata*)**

Flea beetles are common insects in cole crops, and can cause damage by retarding growth of crops. The larvae live in the soil and feed upon the roots of the



*Phyllotreta*



*Monolepta*

'shoot hole' appearance. Severe infestation results in loss of plant vigour, wilting and death. The stem and flowers may also be attacked.

### Biology:

The adult beetle vary in colour from shiny black to black, have very stout femora, with which they jump like a flea. The female lays 50-80 creamy white eggs, in the soil around the host crops. The eggs hatch in 5-7 days. The larva is dirty white in colour with pale white head. It measures about 5 mm in length. There are 3 larval instars. Total larval period lasts for 9-15 days, and later it pupates in the soil. Adults of *P. cruciferae* are known to overwinter in plant debris on the soil surface or in the cracks in the soil. The pest completes 7-8 generations in a year.

### Management:

- Deep ploughing during summer to expose the overwintering population of the pests to sunlight and predation by birds.
- Avoidance of off-season cultivation of cabbage and cauliflower in pest endemic area.
- Crop rotation and sanitation is likely to be of much benefit in avoiding flea beetle infestations.
- Flea beetles are attacked by predatory bugs and parasites.
- Application of Carbaryl @ 2 ml per lit of water or endosulfan @ 3ml per lit of water or malathion 5 % dust @ 10-15 kg/ha

### 8. Cabbage leaf miner (*Liriomyza* spp.)

It is one of the polyphagous pests causing serious damage to several crops including cole crops. Damage is done by mining into leaves and petiole by the larvae. Due to loss of chlorophyll containing cells, the photosynthetic activity of the plants is adversely reduced.

### Biology:

Eggs are inserted just below the leaf surface. Eggs hatch in 2-5 days. Many eggs may be laid on a single leaves. Neonate larva is transparent turn to yellow in later instars. After hatching, the larva start mining into the leaves. As the name indicates its mining shows the typical serpentine shape in leaves. Adults emergence take place 7-15 days after the pupation. Life cycle completes in 12-15 days.



Larva inside mine



Pupa



Adult laying eggs



Magnified adult

**Management:**

- Avoidance of hybrids and judicious application of nitrogenous fertilizers in pest endemic area.
- Removal and destruction of infested leaves followed by an application of NSKE 5 % with sticker (0.5 ml per lit of water).
- Spraying with imidacloprid @ 0.3 ml per lit of water during early stages of the crop growth.
- Application of DDVP (Dichlorovos/nuvon) is also effective in case of severe infestation.

**9. Cabbage aphids (*Brassicorhynchus brassicae*, *Myzus persicae* and *Aphis gossypii*)**

Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. They are the major pests of cole crops and if not controlled in time it may cause serious damage to the crops. It appears in November and remain active till April. Cloudy and moist weather favours rapid multiplication of this pest. Both nymphs and adults are similar in appearances and suck the sap constantly from the leaves which results into wilting, stunting and leaves distortion in the plants.

**Biology:**

A single female produces 5-10 young ones per days. The life cycle is completed in 8-18 days during favourable conditions.



Aphids



Winged aphid



Parasitization of aphids



Damaged plants

**Management:**

- Several natural enemies are recorded in suppressing the aphid population on crops viz., *Crysoperla carnea*, *Coccinella septempunctata*, *Coccinella transversalis*, syrphid fly maggots and hymenopteran parasitoids.

Manual destruction of infested shoots and leaves with appearances of the pest.

- Foliar spray of the following are effective to control aphids attack.
- Metasystox @ 1 ml or cypermethrin @ 1 ml per lit of water

**10. Painted bug or Bagrada bug (*Bagrada cruciferum*)**

This is mainly a pests of crucifers but can cause non-significant damage to the cole crops. The nymphs and adults suck the sap causing the patchy whitish/yellowish growth on leaves.



Bagrada bug

## Diseases of Cole crops

### 1. Damping off of the seedlings in nursery

Many pathogens viz; *Phytophthora megasperma*, *Pythium aphanidermatum*, *Pythium butleri* and *Rhizoctonia solani* are found associated with this disease of seedlings. The loss of seedling from this disease is from 30 to 70 per cent. This disease is major disease of nursery. Appearance of the soft water soaked lesion on the stem of seedling at soil level is typical symptom of the disease. The young seedlings topple down due to collapse of the infected tissues near the ground level. *Pythium* spp. and *Phytophthora* spp. are weak pathogen so they generally attack the younger or tender seedlings. In case of *Rhizoctonia*, the pathogen causes hard rot or bottom rot. The infection is more severe under high humidity and high temperature. The pathogen persists in the soil and on the dead plant debris.



**Damping off of the seedlings**

#### Management:

- Soil solarization of the nursery beds for 6 weeks from 15th May to last week of June.
- Use of raised seed bed to avoid excess moisture
- Sand amendment to the nursery beds for making soil light and well drained Use of light and frequent irrigation and avoid heavy irrigation
- Use of *Trichoderma* formulation @ 4 g / m<sup>2</sup> area
- Use of neem or karanj cake @ 400 g / m<sup>2</sup> area of nursery beds before soil solarization or 10 days before sowing the seeds.
- Seed treatment with Agrosan GN or Ceresan or Emisan @ 2.5 g / kg of seed before sowing
- Two sprays of Bavistin or Benlate or Brassicol @ 1 g / liter water after 12- 15 days interval.

### 2. Downy Mildew

This disease is caused by *Peronospora parasitica* fungi. The appearance of purplish brown spots on the lower side of leaf is characteristic symptom of the disease. The upper surface of the leaf is tan or yellow in place of lesions. The downy growth of the fungus appears usually on the lower side of the leaf. Infected leaf falls off prematurely. During the seed formation the seed stalk show blackish patches and severe condition of the disease spoil the whole curd. The pathogen perennates in the infected plant debris as oospores



**Downy Mildew**

and also as contaminants on the seed.

#### Management:

- Seed treatment with Emisan or Agrosan GN @ 2.5 g / kg of seed before sowing
- Two to three spray of Dithane M- 45 @ 2.5 g / liter water after 8 - 10 days interval starting from the first symptom appearance
- Grow resistant varieties like Snowball
- Clean cultivation by removal of old plant debris

### 3. Black leg

The disease is caused by *Phoma lingam*. An oval or linear, depressed light brown canker near the base of the stem appears as the initial symptom. This canker enlarges and girdles the whole stem. The whole root system decays from the bottom upwards. A severe black discolouration of sap xylem vessel can be observed in this disease. The fungus persists within the seed coat of the seeds and plant debris of previous cole crops.



**Black leg**

#### Management:

- Seed treatment with Agrosan GN or Emisan @ 2.5 g or Bavistin @ 2 g per kg of seed.
- Proper collection and destruction of all the plant debris after the harvest
- Growing of Pusa Drum head like tolerant cultivars

### 4. Alternaria Leaf Spot or Black Spot

*Alternaria brassicae* and *Alternaria brassicicola* are the causative agent of the disease. The leaf spot caused by *A. brassicicola* is larger than *A. brassicae*. The circular and concentric lesion is of 1 cm in case of *A. brassicicola*. This spot having concentric ring give the look of target board. The yellow hallow is found around the spot. In humid and warm condition the entire leaf turn yellow and falls off prematurely. The fungi is seed borne in nature.



**Alternaria Leaf Spot**

#### Management:

- Seed treatment with Captan or Ceresan Wet @ 2.5 g per kg of seed
- Two to three sprays of Dithane M- 45 @ 2.0 g or Dithane Z- 78 @ 2.5 g per liter of water at 7-10 days interval starting from first appearance of the disease
- Alternatively use of copper fungicides like Blitox 50 or Fytolan @ 3 g per liter of water
- Diseased leaf of the crop should be collected periodically and destroyed properly by burning or deep burring.
- Diseased crop debris should be collected and destroyed properly by burning or deep

burring just after harvest.

### 5. Cabbage Yellow

The disease is caused by the fungus *Fusarium oxysporum* f. sp. *conglutinans*. The foliage of affected plants turn yellow. The lateral curling of the leaves and stem occurs. The premature leaf drops of the affected leaves occur and stunted growth of the plant is also observed. Yellow may be confused with the black rot caused by *Xanthomonas compestris* but in case of black rot the veins becomes black rather than brown. The pathogen is soil borne and perpetuates on the diseased plant debris or long in the form of chlamydospores.



**Cabbage Yellow**

#### Management:

- Avoid transfer of diseased plant soil or any plant part containing pathogen from contaminated to the diseased area to the healthy area.
- Soil drenching with Bavistin @ 1 g per liter of water.
- Use *Trichoderma* sp. in the pits at the time of transplanting.

### 6. Bacterial Black Rot

The disease is caused by bacteria, *Xanthomonas compestris*. The disease appear as chlorotic lesions near the leaf margins as initial symptoms which progresses towards the centre forming V- shape. The veinlets and veins turn brown coloured and finally black in colour. The discolouration of vascular bundle extends to the main stem and proceeds upward and downward directions. The infected foliage show yellowing and fall off. The head may rot in late infection the bacterium survives on the crop debris in the soil and through seeds also.



**Bacterial Black Rot**

#### Management:

- Seed treatment with Agrimycin-100 ( 0.01 %) or Streptocyclin (0.01 %)
- Three spreys of Streptocyclin 50 ppm first at transplanting, second at curd formation and third at pod formation stage of crop
- Use of bleaching powder at the rate of 10-12.5 kg / ha as soil drenching reduce the problem



**Symptoms in Field**

### 7. Bacterial white/ soft Rot

The causative agent of this disease is *Erwinia carotovora*. The affected plant show a soft shiny bad smell rotting which under suitable environmental condition spread throughout the entire plant. The entire plant of infected cauliflower seedlings topples down in case of severe infection. The bacterium is weak parasites.

#### Management:

- Seed treatment with Agrimycin- 100 (0.01 %) or Streptocyclin (0.01 %).
- Three sprays of Streptocyclin 50 ppm first at transplanting, second at curd formation and third at pod formation stage of crop.
- Use of bleaching powder at the rate of 10-12.5 kg / ha as soil drenching reduce the problem.

#### Natural enemies fauna in cole crop eco-system

Natural enemies fauna play a significant role in suppressing the insect pest populations in cole crop eco-system. *Cotesia glomeratus* are recorded first time in Jammu region as the potential bio-agents against *Pieris* spp. The natural enemies (parasitoids, predators and pathogens) encountered during experimentation are illustrated as follows:



Cotesia parasitization



Emergence of Cotesia



Magnified view



Adult Cotesia



Hyposter spp



Phryxe vulgaris



Coccon C. plutellae



Braconid



Infected Pieris larvae



Infected Spodoptera



Syrphid larva



Syrphid adult



Grub feeding on aphids Adult *Coccinella*



Green lacewing



Preying mantis



Orb Spider



Parasitized semilooper



*Voria ruralis*



Bird predatio



*At least 5-10 per cent area should be covered under flowering sources so that they can encourage the natural enemy fauna like parasitoids and predators to mitigate the damage caused by insect pests. Further IPM devices and microbial/botanical pesticides should be incorporated to reduce the pest load and pesticide pressure on crops as well as on ecosystem.*

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