Eco-friendly Management of Major Insect-Pests of Cabbage (Brassica oleracea var. Capitata)

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Abstract

The major insect pests of cabbage are diamond back moth, cabbage aphid, cabbage butterfly and cabbage head borer. Their ecology and integrated management with the objectives of arriving at the crucial conclusion on the most suitable techniques to decrease pest infestation for higher yield and productivity with least damage to the environment. Therefore, up to date knowledge about these insect pest and their natural enemies on cabbage, *Brassica oleracea*, is a prerequisite for implementation of an effective and successful ecofriendly management tactics against them. Novel insecticides like Chlorantraniliprole 18.5% SC, Spinosad 45 SC and emamectin benzoate 5% SG can be incorporated into IPM programs and need to be used alternatively or sequentially in insecticide resistance management strategies. Some botanicals insecticides like Neem oil, NSKE and Karanj oil and bio control agents like *Cotesia plutellae, Diadegma semiclausm* and *Aphidius colemani* are used effectively against major insect pest of cabbage. The judicious use of chemicals with novel mode of action needs to be implemented to manage these insects pest. There are many insecticides which have different mode of action than the conventional ones. These novel insecticides in conjunction with other IPM approaches may play a pivotal role in devising effective management strategy against the major insect pest of cabbage.

Key Words: Cabbage, Major, Chlorantraniliprole, ecofriendly and Management.

Introduction

Cole crops are one of the most popular and highly remunerative vegetable crops grown throughout the world. Cole crops are one of the most abundantly consumed vegetables all over the world. Cruciferous vegetables play a significant role in India's *Rabi* crop production. *Brassica oleracea* var. capitata (Linn.), also known as cabbage, is a widely consumed vegetable that is grown in all of India's states and has significant nutritional and commercial significance. It is frequently used in salads, curries, and other dishes as well as fresh and boiling vegetables. It is well recognized to have therapeutic qualities, and its expanded terminal buds are a rich source of calcium, phosphorus, sodium, potassium, sculpture, Vitamin A, Vitamin C, and dietary fibre. 25 g of calories, 0 g of fat, 18 mg of sodium, 0 mg of cholesterol, 170 g of potassium, 6 g of carbohydrate, 1.3 g of protein, 1% of vitamin A, 60% of vitamin C, 4% of calcium, 2% of iron, 5% of vitamin B6, and 3% of magnesium are

found in 100 g of cabbage. (Source: USDA nutrient database). India is the second leading country in producing Cole crops with the production and productivity of 8.5 million tonnes and 19.8 metric tonnes per ha, respectively. Per cent contribution of cabbage and cauliflower production in India from eastern part of India is more than 40%, among them West Bengal (2288.50 thousandtonnes; 25.32%), and Bihar and Jharkhand (999.64 tonnes; 11.06%) are on top (NHB, 2018-19).

The phytochemicals in Cole crops aid in the hydrolysis of glucosinolates in plant tissues, resulting in a substance that reduces oxidative stress, activates enzymes that fight against toxins and stimulates plant growth. In addition, it is regarded as a rich source of sulfur-containing chemicals that give crucifers their spicy flavor and pungent odour (Higdon *et al.,* 2007). Punjab, Haryana, Uttar Pradesh, Maharashtra, West Bengal, Assam, Gujarat, and Karnataka are India's top vegetable-producing states. Due to a variety of biotic and abiotic conditions such as insect pests, the productivity of vegetables, including cool season crops, is impacted (Hasan and Ansari, 2010). Among the most destructive insects to cabbage includes *Plutella xylostella* L. (Plutellidae: Lepidoptera), *Brevicoryne brassicae* L. (Aphididae: Hemiptera), *Pieris brassicae* (Pieridae: Lepidoptera) and *Hellula rogatalis* (Crambidae: Lepidoptera). In general, using synthetic pesticides to protect crops from numerous insect pests is thought of as a fundamental control approach. However, prolonged use of synthetic pesticides for management has unfavorable effects and has contributed to a number of issues, including pest resistance, toxicity to creatures other than the targets, and environmental pollution. As a result, finding pesticide alternatives is necessary. Use of biological sources like botanical pesticides, which have less detrimental effects on the ecosystem, is an alternate strategy for pest management.

1.Diamondback moth, *Plutella xylostella* (Plutellidae: Lepidoptera)

The diamondback moth (DBM), which is responsible for 90 per cent of crop losses worldwide, is a significant insect pest of crucifers (Amoabeng *et al*., 2013). It primarily affects *Brassica oleracea* crops like cabbage, cauliflower, turnips and broccoli. In North America, pests were first noted in 1854. Pest was supposed to be originated from Mediterranean and South Africa region through which it get distributed to the commonly grown areas of cruciferous crops in the world. Over 128 countries throughout the world have reported pest infestation (Gautam *et al.,* 2018).

Distribution: Cosmopolitan in nature. Found everywhere crucifers are grown and is thought to be the Lepidopteran pest with the broadest geographic distribution among crucifers. Lack of natural enemies in many non-indigenous locations, the capacity to travel great distances, and its high rate of fecundity are the main causes of its high pest status (Sayyed *et al*., 2002). In India, it is also distributed in all vegetable growing areas such as Delhi, Jammu & Kashmir, Manipur etc.

Host Range: Plants belonging to the family *Cruciferae* are infested by diamondback moth. Attacks on all cruciferous vegetable crops have been documented, including those of broccoli, Brussels sprouts, cabbage, Chinese cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, turnip and also reported from solanaceous and liliaceous plant. Also feeds on many cruciferous weeds such as yellow rocket, shepherds purse, pepper weed and wild mustards. Before cruciferous vegetable crops are planted in the spring, these weeds play a vital role as alternative hosts (Philips *et al.,* 2014).

Biology and description of the pest: The eggs are oval-shaped, having 0.4 mm length, 0.2 mm width and yellowish white with greenish tinge. Female lays egg on the exterior side of leaf singly or in a group of 2-10. Under typical field conditions, eggs hatch in five to six days. Larvae go through four instars of development and take nine to thirty days to complete. The earliest instars contain a black head capsule and are very small, colourless to yellow. The body of late instars is covered in fine black hair that is dispersed throughout and is green in color and 8 to 12 mm length. Pupate beneath the bottom or outer leaf surface in a loose silken cocoon. The pupa measures between 7 and 9 mm in length and ranges in color from yellow to green. For the pupal stage to fully grow, 7 to 15 days are required. Adult moths are 8 to 12 mm long, thin, grayish-brown, and have pale white narrow wings with yellow inner margins. Each fore wing has three faint white triangular markings on hind margins that, when at rest, seem like three diamond-shaped spots, hence the name DBM. Adults can live for 16 to 18 days, although the average life span is closer to two weeks. An individual female usually produces 20 to 300 eggs. (Shrivastva and Dhaliwal, 2014). In plains, pest activity occurs in the winter, whereas in hills, it occurs from March–April to October–November. The incubation period ranges from 4-8 days. According to reports, the average adult female and male longevity is about 16 and 12 days, respectively. The newly hatched moth begins to lay eggs on same day and each female can lay 20 to 288 eggs (Sarfraz *et al.,* 2011).

Nature of Damage: Crop damage is produced by larvae of DBM. Damage takes place when first-instar larvae leads to scraping of epidermal leaf tissues and produces typical white patches, whereas later instars devour the leaf tissue from the underside of leaves eventually causing holes in the leaves. Due to high infestation of insect, leaves become completely skeletonised *i.e.* complete removal of the leaf tissues except for the leaf veins. The infestation is more severe during dry season (Shrivastva and Dhaliwal, 2014).

Management:

- Plant debris and weeds should be removed and destroyed after final harvest. Before being disposed off the plant debris should be put right away in a covered container.
- A particularly successful method of limiting the spread of pests in the greenhouse is to pinch-off injured plant parts, blooms, and leaves (as well as those with insect larvae or egg deposits) (Gautam *et al.,* 2018).
- Growing bold-seeded **mustard as a trap crop at 2:1** ratio helps to attract the DBM for oviposition at least 10 days before planting of main crop. Population can be reduced by planting marigolds as a trap crop.
- **Intercropping** with **tomato, garlic, dill, clover or carrot** helps to reduce the incidence of DBM. Tomato has been shown to suppress DBM egg-laying when interplanted with cabbage (Sharma *et al.,* 2017).
- Resistant cultivars like **Pusa ketki** and **Pusa deepali** against DBM (Ram and Raju, 2002).

- Recommended to install **Pheromone traps @12/ha** for adult mass collection.
- **Botanical pesticides** including *Allium sativum*, *Azadirachta indica*, Ginger, Javanese long pepper, *Solanum* spp., Sweet orange peels and *Momordica balsamina* boost plant height and yield while reducing the population of *P. xylostella* (Degri and Zakaria, 2015).
- Spraying of **Bt formulation at 1000g/ha** and **NSKE at 5%** (Sannaveerappanavar, 1995).
- **Hymenopteran parasitoids** such as egg parasitoids, ***Trichogramma brassicae* @ 100000/ha** found effective against the pest. **Larval parasitoids** such as *Diadegma insulare, Cotesia plutellae* and *Oomyzus sokolowskii* provides high rate of mortality.
- ***Bacillus thuringiensis* var. *kurstaki* @2g/lit** is also efficient at reducing pest population. ***Diadromus*** and ***Pteromalus,*** two pupal parasitoids, might effectively control DBM (Chauhan and Sharma, 2004).
- Additionally, effective **entomopathogenic fungi** includes *Beauveria bassiana*, *Metarhizium anisopliae* and *Paecilomyces fumosoroseus*.
- **Entomopathogenic nematode,** *Steinernema carpocapsae* has been found effective by causing 100 per cent mortality of larvae after 6 h of exposure.
- Alternate spray of novel insecticides like Chlorantraniliprole 18.5% SC @ 0.5ml / liter water, Spinosad 45 SC and emamectin benzoate 5% SG @ 1 ml per liter water.

2. Cabbage aphid, *Brevicoryne brassicae* (Aphididae: Hemiptera)

Name is derived from two words "*brevi"* and "*coryne"* which are informally translated as "little pipes" and known as cornicles and located near the posterior end of the body. With the exception of *Lipaphis eyrsimi*, the cornicles of cabbage aphid are often shorter than those of other aphids. Cabbage aphids can be distinguished from other aphids by their small cornicles and waxy coating.

Distribution: Supposed to be native of Europe but now having worldwide distribution. Present in different parts of the world such as Canada, Netherland, South Africa, India and China. Distributed throughout the U.S. and also prevalent in southern states (Carter and Sorensen, 2013).

Host Range: Pest is restricted to the plants belonging to *Cruciferae* family which includes both cultivated as well as wild cruciferous crops. Infest the crop in cool season and requires humid but free of rain and cool weather for multiplication.

Biology and description of the pest: Eggs are pale yellowish in color with greenish tinge and laid at winter season in plant waste close to the soil surface (Hines and Hutchison, 2013). There are four nymphal phases in nymphs, which are 1-1.5 mm long, golden green with a subtle ash grey tinge. Nymphs begin depositing eggs as soon as they are 10 to 15 days old. The adult, which is about 2mm long, has an ash grey color, a soft, pear-shaped body with a waxy coating, and two cornicles that secrete honey dew. The head and thorax seem black to dark brown. Remains active from October to

April. Aphids primarily reproduce parthenogenetically, although during particularly harsh winters, they can also reproduce sexually. Winter developed winged (alate) adults have longer life cycle when compared with parthenogenetically produced ones. Alates for migration emerge due to overcrowding, hot temperatures, and low humidity. Average life cycle lasts for 10-45 days.

Nature of Damage: Nymphs and adults infest the crop by sucking the sap from the host plant (leaves/shoots). Yellowing, wilting and stunting of the plant are caused by continued feeding. Most frequently noticed on the underside of younger leaves and plant terminal portions. Produces honeydew, an organic waste product that is sweet and is consumed by ants. The ants in turn shield the aphids from their natural foes. A sooty mould develops due to honeydew which reduces photosynthesis (Hines and Hutchison, 2013).

Management:

- Field should be monitored every week. When aphid populations are excessive **(>50/plant)** on seedlings or on plants close to harvest, control measures should be followed.
- Following harvest, the field should be immediately ploughed in order to remove any potential alternate hosts, such as mustards or other cruciferous weeds (Griffin and Williamson, 2012).
- Destroying plant debris containing aphid eggs at the end of the season (Hines and Hutchison, 2013).
- Use of nectar plant such as **sweet alyssum (*Lobularia maritime*)** helps to attract beneficial insects. Predators like larvae and adults of the syrphid fly and lacewing larvae can be used. Utilizing yellow sticky traps is beneficial for keeping track of the aphid population.
- Leaf and Seed extract of the Chinaberry tree (*Melia azedarach)*, peppermint (*Mentha piperita*) & seeds and flowering lantana (*Lantana camara*) proven effective.
- Treatment with the ***Beauveria bassiana* @ 1-3 ml/litre** found effective and also increases the B: C ratio and economic yield of the crop (Basnet *et al.,* 2018).
- Treatment of the plants using **Margosom (Neem pesticide) @ 5-7.5 ml/litre** is effective and also increases the number of pest repelling natural enemies (Basnet *et al.,* 2018).

3. Cabbage butterfly, *Pieris brassicae* (Pieridae: Lepidoptera)

Distribution: Cosmopolitan in nature. Europe, North Africa, and the Himalayas are where they are most commonly found. The intensity is high in mountainous places in contrast to lowlands. It is also prevalent in Bihar, Himachal Pradesh, Manipur, Meghalaya, Punjab and West Bengal.

Host Range: Cruciferous crop pest. Frequently attacks vegetables such as toria, mustard, knol-khol, turnips, and cabbage. Sometimes targets weeds in the family *Cruciferae* as well as flowers like nasturtium and sweet alyssum.

Biology and description of pest: Eggs have a cylindrical shape and a yellow tint. Eggs are often placed in groups of 50 to 90 on the ventral surface of the leaves. Oviposition prefers clumped vegetation. Initially larvae are pale yellow eventually turn greenish yellow. The butterflies are pale white. Both wings have a smoky shade on the dorsal side of the body and range in colour from creamy white to dull yellow (Hasan *et al.,* 2008). In males and females, the wing expansion measures 6.5 cm and 6.1 cm, respectively. Males are smaller in size and have black spots on the underside of each forewing, while females have two noticeable black spots on the dorsal side of each forewing. From October until April, this pest is active. Winter is the season with the highest butterfly incidence. In winter, the eggs hatch in 11–17 days; in summer, it takes 3–7 days. When the larvae reach maturity, they disperse throughout the plant after initially feeding in groups. Pupate in cocoon on the leaves and stem of the host. Adults live between 3 and 12 days (Capinera, 2001).

Nature of damage: Widely dispersed throughout the Himalayan area and sections of North India. Pest migrates to hilly regions in the summer after spending the winter in the lowlands. Initially larvae feed gregariously on leaves. Late instars disperse and migrate to nearby plants or fields where they gorge themselves on the leaves. Later larvae tunnel into the head of the plant, killing it completely (Verma *et al.,* 2004).

Management:

- To eliminate the leftover crop waste, deep ploughing should be done right after after the last harvest. Cole crops planted early incur less damage than those planted later (January).
- During the initial phase of an attack, collecting and destroying egg masses and caterpillars reduces the pests ability to reproduce.
- Parasitoid such as ***Cotesia glomeratus*** can effectively control the population of *P. Brassicae* (Kumar, 2012).
- Use of botanical extract of **Chinaberry, Lemon grass, Neem leaves extract and white top weed along with cow urine @ 10 per cent** also found effective (Hussain *et al.,* 2022).
- Use of **Neem EC (1% azadirachtin)** induces high mortality of the pest by causing lethal failure.
- Alternate spray of novel insecticides like Chlorantraniliprole 18.5% SC @ 0.5ml / liter water, Spinosad 45 SC and emamectin benzoate 5% SG @ 1 ml per liter water.

4. Cabbage head borer, *Hellula rogatalis* (Crambidae: Lepidoptera)

Distribution: Found in warmer climates of Europe, Asia and Africa as well as Hawaii (Capinera 2001).

Host range: The key cruciferous plants that the cabbage head borer eats are broccoli, cabbage, Chinese cabbage, collard, kale, mustard, radish, rutabaga, shepherd's purse, and turnips. Beet and purslane serve as additional hosts. (Nuessly and Larsen, 2013).

Biology and description of pest: Eggs are oval, somewhat flattened, and have a distinct nipple form at one end. They are reddish in color and have a tangled surface. On terminal leaves, eggs are deposited individually or in tiny clusters. While mature larvae are grayish-yellow with five longitudinal stripes of purple or black color running from head to tail, early instar larvae are yellowish-gray in color without stripes. The bodies of larvae are sparsely coated in setae (hairs), and they are yellow or light brown in hue with shiny, black heads. Larvae tunnel into the ground and then pupate. Pupate inside the tight cocoon, which is formed of earth and silk webbing. When females and males first emerge, their forewings, are, respectively grey and light brown; they eventually turn yellowish-brown in 2-4 days, the eggs hatches out. The caterpillar goes through a 4–19 day pupal stage before becoming fully fed in 6–18 days (McAvoy and Kok 1992).

Nature of damage: Younger larvae feed on the lower surface of leaves, whereas older larvae feed between the upper and lower leaf epidermis. Webs are made by larvae (Silken passage), who then feed within the webs protective covering. Additionally, because larvae feed on the midribs of leaves, the midribs may become weak and the leaves may shatter. Larvae frequently eat away at the main stem and stalk of young plants, causing the plants to wilt and eventually die. When the attack is severe, the plant's head appears distorted and is covered in caterpillars (McAvoy and Kok 1992).

Management:

- Use of **mustard** as a trap crop; collection and extermination of the early-stage larvae (Verma *et al.,* 2004).
- Spraying of **Bt products @ 1.25kg/ha** found effective.
- **NSKE @ 5 per cent** is successful in preventing the pest (Mane *et al.,* 2021).
- Alternate spray of novel insecticides like Chlorantraniliprole 18.5% SC @ 0.5ml / liter water, Spinosad 45 SC and emamectin benzoate 5% SG @ 1 ml per liter water.

Conclusion:

Pests are the main factor causing yield losses in different crops, and they can be controlled by developing Integrated Pest Management strategies at different growth phases. For the identification of key pest growth stages and their sustainable management, biology and ecology are also helpful. DBM, cabbage aphid, cabbage head borer and cabbage butterfly are among the primary pests of cabbage that are generating considerable crop losses. The sustainable management by integrating different stratergies of pest control not only results in reduced losses but also provides solution to the problems such as insecticide resistance, resurgence and residual effect of insecticides. For all these concerns caused by chemical insecticides an eco-friendly management is adopted. The usage of biopesticides, comprise a wide range of microbial pesticides and biochemicals derived from microorganisms and other natural sources. The usage of such natural resources and eco-friendly insecticides will have a significant impact on farming and public health initiatives.

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