Plant Archives Vol. 25, Supplement 2, 2025 pp. 1512-1518 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.190

PEST OF BRASSICA'S: CHALLENGES AND SUSTAINABLE SOLUTIONS

Kanwar Pallavi Singh*, Chander Parkash and Rasna Gupta
I.C.A.R., I.A.R.I. Regional Station Katrain Kullu-175129, H.P., India
*Corresponding author E-mail: pallavi.singh362@gmail.com
(Date of Receiving : 23-04-2025; Date of Acceptance : 28-06-2025)

ABSTRACT

Brassica crops are diverse group of plants including cabbage, cauliflower, broccoli, brussels sprout, knol-khol, kale and radish. These crops are powerhouse of nutrients including vitamins, minerals, dietary fibers, phytochemicals including glucosinolates, flavonoids and carotenoids. They are well recognized for their anticancer and anti-inflammatory potential. Including them consistently in diet may help reduce the risk of cancer and other chronic conditions. But with increasing population pressure and food demand, it is very crucial to strengthen global food security in order to meet the nutritional needs of individuals. Unfortunately, brassicas are highly susceptible to pests like diamond back moth, cabbage butterfly, borer and aphids hereby causing significant economic losses in these crops. Integrated pest management is sustainable and multi-disciplinary approach combining different techniques including cultural, biological, chemical control to manage pests. Use of nano pesticides gaining importance currently. These are pesticides formulations incorporating nanotechnology for improving efficacy, stability and environmental safety. Polymeric nanoparticles, liposomes, metal nanoparticles like such as silver, zinc oxide, copper oxide are some of common examples of nano pesticides.
***Keywords*:** Brassica, pests, management, nano pesticides.

Introduction

India acquires second position in vegetable production globally, with approximate 2.8% of cropped area being used for their production. It is also a big consumer of vegetable crops (Khan *et al.*, 2020). The area under vegetable cultivation stands at 9.542 million hectares. India has first rank in ginger and okra production, while it ranks 2nd in tomato, cauliflower, potato, onion and brinjal production (Kunjwal & Srivastva, 2018). Cruciferous vegetable are crops that are usually grown in cold climates. The most common examples are cole crops (cabbage, cauliflower, broccoli, knol-khol, brussels sprout, kale) and root crops like radish. These crops make up a major portion of human diet and are good source of vitamins A, C, E, K, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine and minerals like calcium, iron, zinc, magnesium, potassium and biochemicals like phenolics and flavonoids are majorly present in cole and root crops. Insect pest are the major constraints to vegetable production; they not only directly damage the crop but also acts as vectors for several viral diseases. These pests are attacking varied range of vegetables and causing considerable amount of economic damage resulting in lower productivity and yield. Diamond back moth is the most dominant pest with ubiquitous nature found associated with crucifers and thereby causing considerable economic losses (Ramaswamy *et al*., 2020). This pest may cause havoc in crops like cabbage, broccoli and cauliflower with yield losses up to 92%, 75% and 30% respectively (Farias *et al*., 2020). Cabbage butterfly, cabbage aphid, cabbage looper, cutworm, leaf miner, flea beetle, leaf webber, tobacco caterpillar are some of the common pests of cole crops and root crops (Kishore *et al*., 2024; Kumar *et al*., 2021; Singh *et al*., 2024; Kharayat & Kumari 2021). Extent of damage varied from season to season and they attack the crops in different stages. Insect pest not only damage growing crops but also acts as vector for several viral diseases causing disease complex. Farmers often apply different type of insecticides to combat the issue but application of high doses, sometime results in pest resistance, resurgence, triggers residue problems, disturbs the ecological balance and

have harmful effects on non-target organism (Kumar *et al*., 2022). Indiscriminate and prolonged use of pesticides also causes health hazards because all these crops are sometimes being eaten raw and even after cooking some level of toxicity remains within (Mayanglambam *et al*., 2021). Integrated pest management is a sustainable approach to manage the insect pest in which by combining different methods viz. cultural control (crop rotation, mulching, intercropping, trap crops, use of organic amendments), mechanical control (manual destruction of eggs and larvae of insect pest), physical control (involves physical blocking of pests from entering crop areas), biological control (use of natural enemies to reduce pest populations), chemical control (use of chemical pesticides at recommended doses to manage pest attack), pests' population will be managed up to certain level (economic threshold level). Botanical insecticides and nano pesticides are key components to overcome environmental risks and health hazards. Their mode of action is quick with zero or minimal effect on non-target organisms (Campos *et al*., 2019). Natural and synthetic pheromones are also used to manage lepidopterans pest. They act by disrupting the olfactory communication regarding mating in opposite sex (Kumar & Shahid, 2020).

Table 1: Major and Minor pest of crucifers

S. No.	Common Name	Scientific name	Order	Damaging stage	Nature of damage	References
1.	**DBM**	*Plutella xylostella*	Lepidoptera	Larvae	Leaf damage- pin hole damage, tunneling in cabbage head	CABI digital library, 2022
2.	**Cabbage butterfly**	*Pieris brassicae/rapae*	Lepidoptera	Larvae	Feed in circular pattern on leaves, leaves discoloration and contamination	Territo & Ingwell, 2024, Sharma *et al*., 2017
3.	**Cabbage aphid**	*Brevicoryne brassicae*	Hemiptera	Nymph and adult	Feed on leaves, flower buds and seed stalk	Gia & Andrew, 2015
4.	**Cabbage looper**	*Trichoplusia ni*	Lepidoptera	Larvae	Larvae feed on stem, leaves, bud and growing tips	Moir & Szito, 2008
5.	**Leaf webber**	*Crocidolomia binotalis*	Lepidoptera	Larvae	Leaves are skeletonized by larvae, webs formation	Jemimah *et al.,* 2021
6.	**Cabbage borer**	*Hellulaundalis*	Lepidoptera	Larvae	Larvae form mines in the leaves while feeding	Jat *et al*., 2022
7.	**Flea beetle**	*Phyllotreta cruciferae*	Coleoptera	Adult	Adult feed on foliage and produce cuticular holes	Mayoori & Mikunthan, 2009

Overview of pests of crucifers

Diamond back moth is one of the most important and dangerous pests of cole crops specially cabbage, cauliflower and broccoli. It was first reported from the island of Taiwan in 1910 (Hori & Shiraki, 1910). It is one of the most destructive pests of cole crops in both tropical and temperate climates known for causing 'windowing' damage leaving the epidermis of plant hanging (Paudel *et al*., 2022). Pest maintained its status as the most destructive member of the different insect pest complexes that attack brassica vegetable crops in various part of world (Hasanshahi *et al*., 2017). Liu *et al.,* 2002 studied the survival and development time from egg to adult emergence of diamond back moth. According to their study moth developed successfully from egg to adult stage at constant temperature from 8 to 32 ℃. Biology of moth varies from host to host and its most favorable host is cauliflower, its population is greatly influenced by environmental factors like temperature, rainfall and humidity (Kannan *et al*., 2011). Host, plant and climate have a great influence on seasonal dynamics of the diamond back moth as concluded in the study conducted by Farias *et al*., 2020 in southeast Brazil. DBM population dynamics and distribution was greatly influenced by extreme temperature. Research showed that fecundity declines when moth is reared at constant temperatures higher than 25℃ (Li *et al*., 2016). Diamond back moth larvae cause economic losses in crops especially in brassica group by feeding gregariously on their leaves. First instar larvae start damage by mining the leaf tissue and later instars consume whole leaf often leave the epidermal layer and leaf veins (Philips *et al*., 2014). It is also reported that larvae feed on above ground plant structures but mainly cause damage when leaves undergo senescence during late season (Dosdall *et al*., 2011). Different host plants (cauliflower, radish, turnip, mustard and canola) have varied effects on fitness of diamond back moth (Saeed *et al*., 2010).

Cabbage butterflies are second most important pest of cole crops after diamond back moth. Significant damage is caused by caterpillars of *Pieris brassicae*

and *Pieris rapae* (Pieridae family) by feeding gregariously on young leaves (Szwejda, 2022). Earlier studies also showed that it damages almost all growing stages including seedlings, vegetative and flowering stages. Also, incidence of granulosis virus recorded in these populations of cabbage butterfly (Kour *et al*., 2018). It is one of the destructive and oligophagous pest known to attack approximately 83 species of family Brassicaceae causing around 40 % yield loss annually (Meenakshi *et al*., 2023). A previous study showed that cabbage butterfly prefers cabbage crop for fast and healthy development and reproduction with low larval mortality and high number of adult yields among other cole crops like cauliflower, broccoli and Brussel's sprouts (Hasan & Ansari, 2011). According to Bhowmik & Gupta, 2017, it takes around 4-5 days for butterfly eggs to hatch and the total life cycle duration from egg to adult emergence was approximately 38 days. Out of all the developmental stages most of the damage was observed from second and third instar larvae with higher rate of leaf damage in kale crop without any insecticidal treatment whereas there was significant reduction in leaf damage after insecticide treatment (Riyaz & Sivasankaran, 2022). Studies on food preferences and consumption were carried out by Hassan *et al*., 2023 in 17 different kale genotypes. All larval stages had different consumption index and digestibility on different genotypes. Plants greatly influence the behaviors of white butterfly. Different plants have natural compounds which are either repulsive or attractive to insect. Plants like Salvia, *Chrysanthemum* spp., *Calendula* spp., *Tagetes* spp., were used as companion plants which affects the oviposition intensity of adult insect (Metspalu *et al*., 2003). Four different crops namely, white cabbage, cauliflower, red cabbage and broccoli effects the nutritional indices parameters of cabbage white butterfly. White cabbage was considered to be most nutritious food for third to fifth larval instars (Mehrkhou *et al*., 2013).

The tiny aphids are known to cause severe economic losses in vegetable crops especially cool season crops like cabbage, cauliflower, knol-khol and broccoli. Other than infesting crops individually, they are also one of the most common vectors of plant viruses, spreading them from plant to plant. Cabbage aphid, *Brevicoryne brassicae* has developed a defense system that mimics its host plant and also release certain glucosinolate compounds like Brassicas (Kazana *et al*., 2007). Trials were set to study the susceptibility of five cabbage varieties to aphid attack. *Lipaphis erysimi psuedobrassicae* and *Myzus persicae* were the two species of aphid recorded. Infestation and disease incidence were different in two subsequent seasons (Adenka *et al*., 2021). Biological parameters of cabbage aphid were studied on eight cultivars of cauliflower which showed that there are significant differences in growth of developmental stages and adult longevity (Jahan *et al*., 2013). Temperature also has major influence on biology of insect. The temperature range of 10, 30 and 35℃ were more lethal than 15, 20 and 25℃, longevity was highest at 10℃ and net reproductive was recorded highest at 20℃ and lowest at 30℃ (Soh *et al*., 2018). Average total nymphal period for cabbage aphid was recorded as 5.80 ± 0.72 days (Chauhan *et al*., 2019). Other than abiotic factors, host plants also play important role in growth and development of insects. Studies showed that nymphal period was significantly higher when aphid reared on cauliflower and lower nymphal period was observed when reared on radish (Razmjou, 2019).

Flea beetles are common pests of Crucifers preferably radish, turnip and other cole crops. They undergo one generation in a year and increase to more generations per year in warmer climates (Sarwar, 2017). Flea beetles usually damage the crops at seedling stage. Adult feeds on cotyledons, stem and leaves of plants which results in uneven plant growth, delayed development, reduced yield and sometimes seedling death. Larvae cause damage with formation of mines in petioles and stem (Li *et al*., 2024). Crucifer flea beetle (*Phyllotreta cruciferae*) and striped leaf beetle (*P. striolata*) found infesting cabbage. Populations were assessed and adult feeding injury was observed (Mason *et al*., 2019). Both these species of flea beetle are also known to damage Canola seedlings, creating a shot holes appearance results in reduction of photosynthetic activity and plant stand density (Mitapelly *et al*., 2024). Different host plants were tested to study the abundance of flea beetles on eight cruciferous oilseed plants for use them as trap crops. *Brassica juncea* and *B. nigra* were developed faster and there early planting stages were found to be more attractive to overwintered beetle (Metsplu *et al*., 2014). Seasonal incidence of striped flea beetle *P. striolata* F. was recorded on cruciferous crops in North Kashmir (Rasool & Lone, 2023).

Management of insect pest of cruciferous crops

Full dependency on chemical pesticides for the protection of crops from pest stress results in potential health hazards (Barzman *et al*., 2015). According to a published article, global pesticide use has grown over the past twenty years to 3.5 billion kg per year adding up to $45 billion to global market (Pretty & Bharucha, 2015). Effective and environmentally friendly management strategies are necessary for controlling

pest complex in vegetable crops. Integrated pest management is a sustainable and holistic interdisciplinary approach comprises combination of methods viz., cultural, physical, microbial, biological, host plant resistance, behavioral and chemical control (Dara, 2019). The basic principles involve prevention and suppression, monitoring, decision making, intervention and evaluation.

Physical and mechanical tactics are the oldest of all other control measures which can be used directly against pest populations. These techniques are environment safe with minimum risk of any health hazards. Different types of mechanical control includes handpicking of insects, bagging and barriers installation to restrict insect pest from crop field whereas exposures to high and low temeperatures, freeze dryings, radiations etc. are important physical control techniques (Yadav *et al*., 2023). Soil solarisation techniques (solar radiation) are useful in many soil pathogens including weeds, plant parasitic nematodes (Weintraub, 2013). Cultural control is one of the important element of integrated pest management. It is based on prevention techniques for better control of pests by breaking cycles, phases and culture (Shimada *et al*., 2021). This type of control can be achieved by changing the natural habitat and environment of insects. Target goal of cultural control is to make the surrounding environment less favourable to pest survival (Gibb, 2015). Three basic principles of cultural control is prevention, avoidance and suppression (Bashyal *et al*., 2022). Cultural management includes optimization of agricultural inputs, cultivation system, plant host interactions, cultivation system (Artuzo *et al*.,2019). Pest population growth is reduced by implying different cultural control tactics i.e crop rotation, use of trap crops and anatgonistic plants, growing plant resistant varieties, burning of crop residues etc. Use of resistant cultivars and crop rotation helps in declining overwintering stage of pests (Rebek *et al*., 2012). The most commonly used and easiest cultural technique is the concept of avoidance including implementation of crop free periods and incorporation of area-wide rouging programmes. These measures can be very effective when implemented on an area-wide scale (Walgenbach, 2018). Several companion plants like catnip, chamomile, thyme, marigold, calendula, nasturtium were suffered less pest damage when they grow together with brassica crops i.e. Kimchi cabbage, kale and white radish. These studies detremines the occurrence of different pests occur in spring and autumn season (Hong *et al*., 2022).

Botanical insecticides

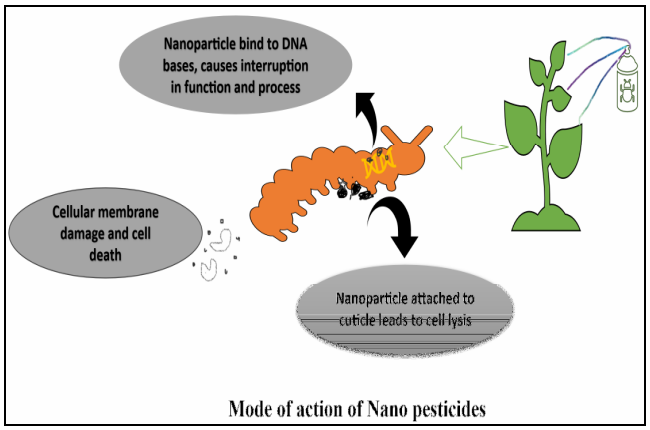
Use of botanical insecticide is on of the safest and ecofriendly way of managing pests. They are safer alternatives and have minimal effects on non target and benefical organisms. Different active principles exudes from specific plants e.g., azadirachtin, nicotine, pyrethrin, alpha terthinyl from neem, tobbaco, chrysanthemum, marigold respectively. Among the different types of botanical insecticides, most commonly used are essential oils, alakaloid, flavonoid, glycosides, esters and fatty acids (Hikal *et al*., 2017). Pyrethrum, rotenone, neem based pesticides and eucalyptus essential oil are also one of the major commercially used botanical insecticides in integtarted pest management system (Laxmishree & Nandita, 2017). Leaf extracts of azadirachta and lantana camara were found effective against *Plutella xylostella* and *Pieris brassiceae* (Mayanglambam *et al*., 2021).

Biological control and habitat management

Entomopathogenic nematodes are used as important biological control tool to fight pests of vegetable crops. The nematodes of family Steinernematidae and Heterorhabtidiae carries bacteria viz. xenorhabdus and photorhabdus. Association of nematodes and bacteria proves lethal to the pest. Three species of entomopathogenic nematodes namely *H. bacteriophora*, *S. thermophilum* and *S. glaseri* were tested against larvae of *Pieris brassiacea*. Though all these species showed larvicidal activities but *S. thermophilum* engulfed almost all larvae after 24 hours (Dass *et al*., 2024). High mortality rate of cabbage stem flea beetles was obtained *H. bacteriophora*, *S. feltiae*, *S. carpocapsae* and *S. kraussei* formaltions used on host plants (Price *et al*., 2023). Habitat manipulation is one of the most suitable and easy strategy to promote the populations of natural enemies and insect predators (Mayanglambam *et al*., 2021). It includes techniques like intercropping and push-pull strategies. Latter are novel emerging tool for integrated pest management system. In this technique, main crop grow along with any other intercrop or trap crops with some repellent properties so that pests deterred away from main host crop and get attracted towards stimuli. Desmodium speices was planted as intercrop alongwith main crop maize where adult moths of stem borers got attracted towards semiochemicals exude by the above mentioned trap crop (Bhattacharya, 2017). Olfactory cues and visible cues contains different types of plant volatile and hue which are responible for trapping insects towards intercrop and divert from main crop (Eigenbrode *et al*., 2016).

Nanopesticides as management tool

Nanopesticides are novel pesticides appears as an safer alternative to chemical insecticides, can be used in more controlled manner for specific time span. Unlike chemicals, nanopesticides doesn't harm non target organisms, are highly efficinet and can be used in reduced doses (Yadav *et al.*, 2022). These formulations are designed in a way that they have lower number of active ingredients which are encapsulated by nanocarriers like liposome, polymer, clay and zein nanoparticles. They have several advanatages over synthetic pesticides including, elimination of organic toxic solvents, cost effectiveness, low dose requirement, target only active pest etc. (Kannan *et al.*, 2022). Some of the examples of innorganic nanoparticles are Nano silver, cadmium sulphide, nano titanium dioxide and nanogel which were found effective against pests like tobacco caterpillar, *Spodoptera litura* and fruit fly, *Bactrocera dorsalis* (Sarmah *et al.*, 2023).



Mode of action of Nano pesticides

Conclusion

Cruciferous vegetables are powerhouse of nutrients including, fibres, vitamins, minerals and have many potential health benefits. They are also good source of phytochemicals, glucosinolates and have antinflammatory and anticancerous properties. Vegetable suffers heavy losses caused by insect pests and diseases. For coping considerable economic damage, proper managemnet module should be followed. Integrated pest management is best strategy comprises of combination of control tactics to keep pest population beyond economic threshold and lower the chances of pest resurgence. New strategies like use of nanopesticides, botanical, fungal and bacterial formulations have minimal health hazards and are less toxic to environment.

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