International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 02-05-2022, Accepted: 16-05-2022, Published: 03-06-2022
Volume 7, Issue 6, 2022, Page No. 24-30

Review on biology and management of *Henosepilachna vigintioctopunctata* (Hadda beetle) on Brinjal crop

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Abstract
Hadda beetle is a major pest of solanaceous crops all over the world, is one of the most serious defoliators of eggplant, resulting in significant economic damage. It is a polyphagous pest that feeds on a variety of plants, with brinjal being the most popular. Both grubs and adults consume the leaf's green substance and skeletonize it, leaving just the top epidermal layer. The plant's growth and development are severely impeded, and the yield is significantly reduced. One week after transplanting, the % infestation starts. The environment affects the population dynamics of pest species. Insect infestation and multiplication are affected both directly and indirectly by several prevalent meteorological characteristics such as maximum and minimum temperature, wind velocity, minimum and maximum humidity, sunshine, and rainfall. According to studies on its biology, females lay eggs in batches during entire life and the larvae go through four moults. Premating period, pre oviposition period, oviposition period, incubation period, larval period, pre pupal period, pupal period, and adult period duration vary for each stage of its life cycle. Pests were present throughout the year due to their diverse host range. Profit diminishes as the number of insect pest applications rises. IPM is a system which involves many of appropriate techniques and approaches as possible in a compatible way to keep pest populations below those that cause economic harm. Pest management strategies that are well chosen and implemented will have positive economic, ecological, and societal benefits. More research on the impact of ecological factors on different life stages of *Henosepilachna vigintioctopunctata* is required so that they may be used to develop IPM strategies for successful management.

Keywords: brinjal, *Henosepilachna vigintioctopunctata*, symptomology, biology, management

Introduction

Insects are economically significant organisms; some are useful to humans and their possessions, while others are destructive. Some of them are important for pollination. Pest insects spread disease across civilization and harm agriculture, forests, and other natural resources. Pests are animals whose populations have grown to the point that they are causing economic losses to crop or becoming a nuisance and health concern to humans and their livestock (Deshmukh *et al*. 2012) [4].

Coleoptera is the largest order in the animal kingdom, not only in numbers of insects, but also in numbers of the entire animal kingdom. Coleoptera is a combination of the Greek words koleon, which means "Sheath," and pteron, which means "Wing." It refers to the wing of a beetle. Beetles are significant economically in two ways. Plant feeding on the other side, is a pest of farm crops and forest trees when it is abundant. On the plus side, predatory organisms play an important role in man's efforts to manage plant-feeding pests.

Epilachna vigintioctopunctata and *Epilachna dodecatigma* are vegetable pests that can create serious damage (Khan *et al*., 2000) [12]. It is easily identified by the 14 or 28 dots on its dorsal body. It has never been reported as a major pest of bitter gourd in Eastern Uttar Pradesh, and it was observed for the first time causing extensive crop damage. The Epilachna beetle is a widespread pest that attacks Solanaceous and Cucurbitaceous plants (Khan *et al*., 2000) [12]. The hadda beetle's peak infection season varies from region to region. It was seen in the Eastern United States during the months of July and August. By scraping on the leaf surface, both adult beetles and grubs feed on the epidermal tissue of the leaves.

Vegetables are utilised as selected diets by everyone and play a vital role in providing key preventive components such as vitamins and minerals. Brinjal is a popular vegetable crop in Asia, Africa, and portions of Europe. It is a popular worldwide vegetable crop grown in sub- tropical and tropical areas (Sarker *et al*., 2006), including India, which is the largest producer and original habitat among tropical and sub-tropical nations, and is grown under a variety of agro-climatic conditions as one of the main vegetable crops (Prasad UK *et al*., 2008) [24]. Because it is a succulent crop with a high plant canopy, it is vulnerable to insect and pest infestations. Henosepilachna vigintioctopunctata (Coleoptera: Coccinellidae), also known as the Mexican beetle in Europe and locally as the hadda beetle, is one of the most destructive pests found all over India and other countries (Anam *et al*., 2006; Rahaman *et al*., 2008) [3, 30]. It has also been observed in Jammu and Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Bengal, and Karnataka, among other places in India (Shankar *et al*., 2010) [38].

It is a common pest that attacks many cultivated and wild crops belonging to the Solanaceae, Cucurbitaceae, Fabaceae, Convolvulaceae, and Malvaceous families (Ahmad *et al*., 2001; Rath, 2005) [1, 34]. It has turned out to be a destructive pest with a wide host range, with brinjal being one of the most preferred hosts (Ghosh SK and Senapati SK. 2001) [6] Australia, Africa, Asia, Afghanistan, America, China, the Middle East, Siberia, and Sri Lanka are among the countries represented. (Jamwal *et al*., 2013) [9] The first person to notice Epilachna for their phytophagous tendencies was Redtenbacher (1843). On plants in the Solanaceae family, they are polyphagous but can also be oligophagous (Mandal and Mandal, 2003) [17]. They are expert feeders of many Solanaceae plant species that can continuously feed tomato and brinjal within 5 minutes, causing significant losses (Shinogi, 2005) [39].

Seasonal incidence and occurrence:

The extent of *Henosepilachna vigintioctopunctata* infestation and its incidence on brinjal crops is determined by biotic and abiotic variables. The ecological elements that exist in the agricultural environment play a significant role in pest bionomics and distribution. Various ecological elements such as maximum and minimum temperature, wind velocity, minimum and maximum relative humidity, sunshine, and rainfall, and so on have a significant impact on beetle activity. The peak period of infection varies by area, and the reason for this variance is related to planting date, seasonal variations, and other biotic variables. Several researchers studied the relationship between beetles and environmental factors, including Prasad and Logiswaran (1997), Ghosh and Senapati (2001) [6]; Muthu Kumar and Kalyanasundrum (2003); Varma and Anandhi (2008) [45]; Tiwari *et al*., (2012) [43]; Putta Raju, (2008) [25]; Raghuraman and Veeravel (1999) [29]; Haseeb *et al*., (2009) [8, 26]. Their population has a favourable association with environmental conditions at times and a negative correlation at other time. Beetles are active throughout the growing season and begin causing harm as soon as the plants are transplanted. Among the winter, they hibernate in piles of dried plants, cracks and crevices, or the soil. Survivability is higher in both on and off seasons due to its polyphagous nature. The imago and larvae of this species feed intensively on the epidermal tissues of the host plants from July to August, which is when they are most active (Khan *et al*., 2000) [12].

Symptomology

Feeding damage may appear differently in different insect pests depending on their feeding habits. The presence of an insect pest and its attack range can be determined based on the damage symptoms. Hadda beetle grubs and adults are voracious eaters and can cause significant damage from planting to harvest by chewing on the delicate outer leaf tissues. Grubs gather on the bottom surface of the leaves, scraping the parenchymatous tissue and lower epidermis while leaving the top epidermis intact and creating "windows." Leaf tissue is eaten between both the veins, as well as the midrib is often entirely torn away. The photosynthesis is harmed when the leaf area is entirely degraded. This has an impact on the generation of energy for plant growth and development, resulting in weaker plants and a delay in flowering and fruiting. When a plant is young, it compensates for the loss of leaf area by growing new leaves. Severe defoliation, on the other hand, might cause a significant delay in fruit production or even mortality of the plant. The scraped leaves eventually dry up. In the event of a severe infestation, the plant's development, fruit production, and maturity are all hampered, resulting in a drop in output.

Biology: Mating

Adult beetles can be seen flying and eating in the fields when the weather warms up. After 2-3 days of emergence, mature adults start mating. A couple copulates multiple times, with each copulation lasting between one to three minutes (Nithish *et. al.*, 2020).

Fig 1: Mating of male and female

Egg

The female started producing eggs 18-23 days after emergence, with a preoviposition period of 20.3 days on average. The average egg laying period was 22.6 days, and egg laying continued for 19-26 days. The eggs were laid in clusters in general (Plate.1). Single eggs on the underside of the leaves were stalked, shiny yellow, elongate-oval tapering at top end, pointy distally and clustered vertically with smooth texture. As the eggs matured, the colour changed from yellow to light yellow, and finally to creamy yellow at the time of hatching. A single female produced 271-329 eggs in her lifetime, and the eggs were deposited in groups of 5 to 61 (Reddy *et.al.*, 2016; Mandal *et. al*., 2016) [36].

Fig 2: Eggs in batches

Female lays about 200-450 eggs in 5-40 batches during her life span and each cluster contains 15-50 eggs on the underside of the leaf (Tyade and Simon, 2013; J. S. Tara and Sonia Sharma, 2017; Qamar *et al*., 2009) [44, 41, 8]. Individual eggs are stalked and shiny, cigar-shaped, tapering at the upper end, pointy distally, and grouped vertically when freshly laid. At hatching, the bright yellow colour turned to yellow (Kaur and Mavi, 2005; Varma and Anandi, 2008) [11] and then to creamy yellow. Within 2-9 days, the egg will hatch (2-3 days in summer, 4-9 days in winter). The eggs are pale yellow in colour, spindle-shaped, and attached vertically on the ventral side of the leaves towards the midrib in clusters of 16-40. They were spindle-shaped, with a length of 1.3 mm and a width of 0.6 mm (Deshmukh *et. al*., ad Chougale *et. al*., 2012) [4].

Larva

Recently hatched fleshy larvae are creamy white, pale yellow, or dull blackish green in colour, with six rows of long branching spines on the thoracic and abdominal segments (Kaur and Mavi 2005; Qamar *et al*., 2009) [11, 8]. The spines are yellow at first, but as they darken on the tips, they become more visible. It goes through four distinct stars throughout its larval phase, which lasts 9- 18 days. The first instar larval stage did not move much and ate tender foliage. The chitinisation of the second instar of larvae is great. This stage scraped the green materials in patches on the underside of the leaves in a distinctive manner. The third instar stage moves quickly and feeds on green materials from the leaves' surfaces as well as the foliage's twigs. The fourth instar stage is a voracious eater of the foliage, scraping the green substance off the leaves and skeletonizing them. At the time of pupation, the fully developed fourth instar grub stops eating, and the grub's colour fades, and the body shrinks (Qamar *et al*., 2009) [8]. Grubs are gregarious in nature in their early stages, but as they mature, they prefer to separate into smaller groups. The freshly hatched larvae/grubs had a dull blackish-green colour. It resembled a normal ladybird larva in appearance, with an elongate-elliptical form and somewhat lengthy legs. Branched bristles covered the whole body (Plate 1). In newly born grubs, these bristles were yellow, but they gradually became black. The grub was simply feeding on the surface. It eats the soft surface tissues between the veins of the leaf surface. There were four moults and five larval instars in all.

Fig 3: Newly hatched larva

Pupa

The fully grown fourth instar grubs stop eating and, and use a sticky secretion, and attach to the underside of the leaves or stem by the posterior portion of their bodies, spending approximately 1-2 days in the pre-pupal stage (Varma and Anandi 2008; Qamar *et al*., 2009) [8]. Pupa has a hemispheric or oval form and is black in colour (Kaur and Mavi, 2005) [11]. The newly developed pupa is bright yellow or orange, but the dorsal surface has become creamish brown with spots. It has a smooth front section and a spiny posterior area. Pupa is like grubs but is often deeper in colour, however it can be yellowish in appearance. The posterior section of Pupa has spiky hairs, whereas the anterior part does not. The pupal phase lasts 3-6 days (Verma and Anandhi, 2008; Qamar *et al*., 2009) [8], however it can last longer in some situations before the adult beetle emerges. *Epilachna vigintioctopunctata* pupae were oxarate obtact type. Small bristles coated the whole body dorsally. It was yellow, 6-7 mm in length, and in the inactive (non-feeding) stage. It has a seven-day duration (Deshmukh et. al., and Chougale et. al., 2012) [4].

Adult

The fully emerged adult has a bright golden colour that fades to a brown copper tone with a bronze tinge mottle and black spots (Kaur and Mavi, 2005) [11]. (Varma and Anandi, 2008). When seen from the side, the body is spherical with a convex dorsal surface and a flat ventral surface, giving it the appearance of a 'D' (Qamar *et al*., 2009) [8]. Adults are 6-7 mm long and 5- 6 mm broad, with a black head and fine short hairs covering the entire body. On the elytra of beetles, there are 28 black dots. Due to coupling with females of *H. dodecastigma* and males of *H. vigintioctopunctata,* beetles with 14, 16, 18, 20, 22, 24, or 26 spots can also be seen. Males are slightly smaller than females in age (Nithish et. al., 2020).

Integrated Pest Management

Synthetic insecticides were used to control beetles because of their rapid knockdown action (Liu *et al*., 2003). Pesticides used indiscriminately in vegetable fields for insect pest management cause lots of new environmental and ecological issues, including widespread pest resistance, unfavourable impacts on non-target species, harmful residues in food, and secondary pest outbreaks (Kranthi *et al*., 2002) [13]. These issues have emphasized the need for improved, safer, and environmentally friendly pest control methods to be developed. Insect pest management is the use of technology in combination with biological understanding to obtain a desirable decline in insect pest numbers or impacts, as well as to keep the pest population at levels that do not cause economic harm. Physical, mechanical, cultural, biological, chemical, hormonal, genetically, and legal tactics can all be used to control insects. A few tactics are preventative, such as physical and mechanical measures, cultural practises, and legal control, which keep the insect from becoming a pest, while others are curative, such as biological, bio pesticidal, and chemical control, which reduce the number of insects infesting crops or human belongings. Nontarget species, millions of unskilled users, consumers, and the environment are all completely safe when using Integrated Pest Management tactics. It also supports in the growth of biotic components, resulting in long- term natural pest control. IPM necessitates close monitoring of population dynamics, growth, and associated judgments regarding the appropriate control techniques to be utilised for pest population management for Long-term crop productivity (kumar, 1987) [14].

IPM Methods Physical methods

Adult beetles, grubs, and pupae are collected and destroyed. Early in the morning, shake plants to remove grubs, pupae, and adults in a container of kerosene water**.**

Cultural Methods

During the cropping season, management methods may minimize the beetle population in the fields, but the population will regenerate over time from alternate hosts to the primary crop. Alternative hosts and their interactions should be identified for successful pest management, and fields should be kept clean.

Mechanical methods

The population of *Henosepilachna vigintioctopunctata* can be kept below the level of economic injury utilising mechanical means (Karmakar and Bhattacharya, 2000) [10].

Resistance varieties

Rajendran and Gopalan (1998) [33] studied brinjal seed samples for *Henosepilachna vigintioctopunctata* resistance and found that only 9 accessions were resistant, 17 were moderately resistant, and 77 were susceptible. Only EP24/65 alone was moderately resistant among the hybrids studied, however all wild accessions were resistant, except for *S. macrocarpum* (BE-046/EP154), which was moderately resistant.

Natural enemies

In IPM, parasitoids have a massive amount of potential. Natural enemies have a substantial role in Hadda beetle immature stage mortality and might be useful in pest management in commercial vegetable agriculture. The Hadda beetle's rising pest status and abundance have generated a variety of issues about the variables that contribute to its growth, its natural enemy complex, and control in natural context. To improve or strengthen the effect of natural enemies in a prey population, the interaction components between natural enemies and prey should be fully recognised. *Henosepilachna vigintioctopunctata* parasitoids *Tetrastichus ovulorum, Pediobius foveolatus, Uga menoni,* and *Bracon sp.* have been active in the fields, parasitizing eggs, grubs, and pupae, respectively. The parasitisation rate is maximum in the fourth stage instar, when adult parasitoids emerge from the grubs through holes in the back.

Botanicals

Plant extracts include botanical pesticides or phytochemicals that can be used to repel, prevent feeding, or reduce the reproduction and survival of insects. The usage of natural plant products including microorganisms and fewer toxic insecticides is thought to be environmentally safe. Researchers are focusing a lot of attention on biologically active indigenous plant products since they are ecologically friendly, biodegradable, and cost effective (Ghani, 1998) [5]. Naturally produced plant products play a vital role in replacing or reducing the usage of pesticides Because they are a rich source of bioactive components (Wink, 1993) [46]. Various qualities such as larvicidal, antifeedant, reproductive, and growth inhibitory activities have been reported by several studies against a range of economically important insects (Singh and Saratchandra, 2005) [40]. Because these botanicals have several active components, there is less risk of resistance evolving and they are easily biodegradable in the environment.

Plant extracts such as *Azadirachta indica, Calotropis gigantea, Prosopis juliflora, Vitex negundo, Pongamia pinnata, Lantana camara, Allium sativum* extracts, neem cake extract, neem oil, and Nimbecidine, as well as the neem cake extract, neem oil, and Nimbecidine, can help to reduce the pest population (Murugesan and Murugesh, 2008) [20] and Neem oil, Neemark, Bioneem, Nimbicidin, Neem Gold, Achook, neem leaf extract, and neem seed kernel extract (NSKE) are all Azadirachta indica products that can help reduce insect populations (Mane and Kulkami, 2010) [19]

Biopesticides

Rajendran and Gopalan (1997) [37] studied the effects of two bio pathogens, *Bacillus thuringiensis* (Bt) and *Beauveria bassiana* (a white fungus), on different stages of *Epilachna vigintioctopunctata* and found that Bt used as a leaf dip killed the most first instar grubs and pre-pupal stage grubs, whereas direct spraying of *Beauveria bassiana* killed the most first instar grubs and pre-pupal stage grubs. Adults had a lower susceptibility to fungus. Beetle mortality can be seen as early as the first day when the mycopathogen *Beauveria bassiana* is applied in the field (Thurkathipana and Mikunthan, 2008) [42]. *Metarrhizium anisopilae,* a green muscadine fungus, has the potential to inhibit both grubs and adults (Rajendran, 2002) [31].

Chemical Control

Synthetic pesticides are mostly used to control beetles because of their immediate knock- down action (Liu *et al*., 2003) [15]. Insect growth regulators such as diflubenzuron, teflubenzuron, and flufenoxuron have been shown to prevent full egg hatching in *Henosepilachna vigintioctopunctata* adults (Mala *et al*, 1992) [16], and Teflubenzuron can also make eggs are not developed. Diflubenzuron is a powerful larvicidal chemical that interferes with the moulting process while also decreasing egg hatchability and fertility (Gupta and Dogra, 1994), resulting in a population reduction of about 95% in field.

Fipronil is the most effective chemical for controlling the beetle in the field, controlling both adults and larvae (Panda *et al*., 2005; Qing and Hong, 2004; Qing *et al.*, 2003) [23, 28, 27] while Cypermethrin is the most effective for reducing pest population at all stages of plant growth (Panda *et al*., 2005; Qing and Hong, 2004; Qing *et al*., 2003) [23, 28, 27]. (Mandal and Kumar, 2001) [18]. Insecticides such as etofenprox, quinalphos, and cypermethrin can have a good ovicidal impact when sprayed (Mala *et al*, 1992) [16]. Dimethoate, fenpropidin, and fluvalinate are insecticides that are effective against larvae, whereas quinalphos, cypermethrin, deltamethrin, and fenvalerate are insecticides that are effective against both larvae and adults (Nagia *et al*, 1992) [22].

Conclusion

Chemical management has its own set of restrictions, owing to the pest's natural tendency to resurface at a rapid rate, as well as the issue of residual toxicity, which arises from the regular removal of edible fruits. Insecticide contamination has become a major source of worry in the environment. Insecticides with a long residue can spread far beyond their intended objectives, reducing populations of beneficial insects and wildlife. The development of pesticide resistance in strains of numerous pest species is another key issue related with the usage of insecticides. Insecticide resistance has been found in over 500 different kinds of insects.

However, natural enemies of insect pests are more sensitive to pesticides than the insects themselves and can be readily eradicated from the agricultural environment. Several studies have shown evidence of pesticide hazards to human health and economic impacts. As a result, there is a critical need to create new IPM tactics that prioritise avoiding the use of chemical pesticides. Natural enemies will aid in the control of the *Epilachna vigintioctopunctata* population in brinjal. Research is still needed to critically analyse pest-natural-enemy interaction studies, as well as innovative IPM strategies to protect natural enemies. Keeping this in mind, more research is needed to determine the relationship between pesticide natural enemies and parasitism intensity of linked natural enemies. Researchers were drawn to several plant products or botanicals with a range of significant features such as insecticidal, antifeedant, repellent, growth inhibitory, chitin synthesis inhibitory, and environmentally friendly nature. Bio insecticides including extracts of pant sections with active components that control the pest should be the subject of research. More research is needed on the impacts of ecological variables on different life stages of *Henosepilachna vigintioctopunctata* so that IPM strategies may be devised for successful management. This will support in the construction of *Henosepilachna vigintioctopunctata* life table and biology, as well as the identification and quantification of bio-mortality parameters.

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